The
GEOGRAPHICAL JOURNAL

Vol LXXXVII No 5 R.G.S. *May 1936*

OXFORD UNIVERSITY ELLESMERE LAND EXPEDITION:

Papers read at the Evening Meeting of the Society on 18 November 1935, by

DR. NOEL HUMPHREYS, MR. EDWARD SHACKLETON, AND MR. A. W. MOORE

Summary of the Work of the Expedition

17–20 July 1934

THE Expedition sailed from St. Katherine's Dock, London, in a Norwegian sealer, the *Signalhorn*. Severe head winds delayed the outward journey, and a solid jam of ice which blocked the whole of Smith Sound prevented the Expedition from reaching either Fort Conger or Bache Peninsula. Winter quarters were finally established at Etah (Latitude 78° 19′ N.)

August 21–October 11 (freeze-up)

During the summer and early autumn, several boat journeys were carried out to Cairn Point in order to lay depôts of supplies for the spring sledge journeys. Biological collections were made in the neighbourhood of the base and hunting operations conducted.

11 October 1934–2 April 1935

From freeze-up until after the sun left on October 24, sledging activities took place within the neighbourhood of the fjord. An attempt was made to reach Robertson Bay over the ice-cap, but this was prevented by bad weather, as were subsequent attempts during the winter night. The journey was finally accomplished chiefly by moonlight, at the end of January; the party returning on February 24 after a journey of approximately 300 miles.

Mid-winter activities were controlled by the moonlight, and several sledge journeys were made to the Eskimo settlements and also north to the depôts both before and after the return of the sun on February 18.

April 2–End of May

Three main sledge journeys were carried out by the expedition:

Grant Land Party, consisting of Moore and Stallworthy, penetrated into northern Grant Land, north of the United States Range, finally reaching

a point approximately in latitude 82°25′, within sight of the Polar Sea at Clements Markham Islet. A new range of mountains, 10,000 feet high, was discovered, Moore himself attaining a height of 9000 feet. The party returned with geological collections, after covering about 900 miles.

Grinnell Land Party. Humphreys and Haig-Thomas ascended the Grinnell Land ice-cap, where, after sighting some new mountains, they were halted by deep snow. A crossing was then made into western Ellesmere Land, where a journey was completed between Bay Fjord and one of the fjords running out of Baumann Fjord. Geological and archaeological collections were made, and approximately 800 miles covered.

Scoresby Bay Journey. Bentham and Shackleton carried out geology and survey in the Bache Peninsula district, and the glaciers at the head of Princess Marie Bay were investigated. A journey was made later up the east coast of Ellesmere Land. Scoresby Bay was explored and mapped, and the Victoria and Albert mountains, which rise to a height of between 5000 and 6000 feet, were located on the shores of the Bay. Geological investigations were carried out north of Cape McClintock in lat. 80°. The total distance was approximately 800 miles, and a geological collection was made.

End of May–August 21

Biological and geological collections were made in the base area, while Haig-Thomas sledged 100 miles to Inglefield Gulf, where he carried out ornithological work. The ice broke up on July 11 and on August 5 a 70-mile boat journey to Robertson Bay was completed.

August 21–11 October 1935

Return journey on the schooner *Dannebrog*. The party finally reached Barra in the Outer Hebrides on October 11.

I. ELLESMERE LAND AND GRINNELL LAND

DR. NOEL HUMPHREYS

THIS expedition was one of the many sent by the Oxford University Exploration Club. It originated with E. A. A. Shackleton and A. W. Moore, members of the Club's Sarawak Expedition in 1932, who planned to get up an Arctic expedition. Different fields in the Arctic were considered and the area eventually decided on was Ellesmere Island. For such an expedition it would be necessary to abandon the usual custom of the Club of sending summer expeditions and to be prepared to winter in the Arctic.

Shackleton and Moore were joined by the writer and it was with this membership that the expedition was fathered by the Club and supported by Oxford University, the Royal Geographical Society, and many private subscribers to whom our deep gratitude is due. Over seventy firms contributed most generously to the expedition. With this backing, the Canadian Government gave the necessary permits, some financial assistance, and attached to the expedition Sgt. H. W. Stallworthy, of the Royal Canadian Mounted

Police. Stallworthy had thirteen years' experience in the Canadian Arctic and spoke Eskimo. R. Bentham and D. Haig-Thomas joined the expedition later, bringing the total European personnel to six.

According to the custom of the Oxford University Exploration Club separate members of the expedition were appointed as Leader and as Organizer, the writer being appointed in the one capacity and Shackleton in the other. Shackleton and the writer were surveyors, Moore was the photographer and assistant geologist, Bentham the geologist, and Haig-Thomas ornithologist; Bentham was also in charge of the wireless and the writer of insect and plant collecting.

Ellesmere Island is the most northerly part of the British Empire; it is the largest wholly Arctic island and the largest normally unpeopled island, though at the present time there are two Royal Canadian Mounted Policemen stationed at Craig Harbour, in the extreme south of the island, giving the island the somewhat Gilbertian distinction of being the only country populated solely by policemen. The island is about 80,000 square miles in extent, being roughly the size of the mainland of Great Britain, and is 540 miles long, while its greatest breadth is only 250 miles. Ellesmere Island is mountainous, the mountains in the east of the island being higher than those in the west. It is divided into four peninsulas, known, from the north southwards, as Grant Land, Grinnell Land, Ellesmere Land, and North Lincoln Land. Each peninsula has an ice-cap. The island has been crossed at each isthmus, but it is only in the south-east of Grant Land that the interior is known in any detail, as the result of Greely's Expedition of 1881–84. Not one of the four peninsulas has been crossed anywhere near its centre. Ellesmere Island was discovered by Bylot and Baffin in 1616 and the part of the coast he saw he named Ellesmere Land. The island was not seen again until 1818, when it was sighted by John Ross on the voyage which discovered the Cape York Eskimo, who were almost unaware of the existence of human beings other than themselves. The first landing on the island was by Dr. Hayes of Kane's Expedition in 1854. The Nares Expedition of 1875–76 was the first to penetrate Kennedy Channel. It established its winter quarters at Fort Conger and Cape Sheridan, and explored the greater part of the north coast of Grant Land, and mapped the east coast from Cape Isabella northwards. This expedition also explored a good deal of north-west Greenland, and Commander Albert Markham reached the most northerly point then attained on the Polar Sea. In 1881–83, a party under Lieutenant, afterwards General, L. Greely wintered at Fort Conger, explored the southern isthmus that separates Grant Land from Grinnell Land, and extended the coastal exploration to Nares. Owing to the failure of the relief ship to arrive, the party went south by boat, reached Cape Clay on Bedford Pym Islands, and were eventually rescued in June, but only after dreadful privations, as a result of which seventeen men died. In 1898–1902 an expedition under Captain Otto Sverdrup explored and mapped the Bache Peninsula area, and also did a great deal of scientific work on geology, biology, etc. They mapped Jones Sound, Baumann Fjord, Western Ellesmere Island, and Axel Heiburg Land. At the same time Peary was travelling up and down the coast of Ellesmere Island on attempts to reach the Pole. On the 1898 journey he climbed the

the Grinnell Land ice-cap, and claimed to have discovered Cañon Fjord, afterwards mapped by Sverdrup. He also travelled over the whole of the north coast of Grant Land. But Peary added little to the exact survey of this region. In 1906 he wintered at Fort Conger in another unsuccessful attempt. In 1913–17 MacMillan travelled over a great deal of Ellesmere Island, in his search for non-existent Crocker Land, and made a return visit in 1923.

The Royal Canadian Mounted Police established a detachment at Bache Peninsula, and several notable patrols were made. Owing to difficulty in relieving this station however it was transferred to Craig Harbour in Jones Sound.

The name Ellesmere Land, first given to the landfall of Baffin, was afterwards extended to the whole island, but by a more recent system of nomenclature the island is now called Ellesmere Island and the name Ellesmere Land is confined to the peninsula which includes the portion of the coast sighted by Baffin. The title of this expedition refers to the second use of the name, the objective of the expedition being the exploration of any part of the island. Long before the discovery of the island by Europeans Ellesmere had been inhabited by Eskimo, whose village sites dot the coast, especially on the west where, the mountains being lower, there are large areas free from snow in the summer. During European knowledge of the island it has not supported a population but it is a summer hunting ground for the Cape York Eskimo. These natives are cut off from the Greenlanders farther south by the ice-cap which, at Melville Bay, reaches the sea and leaves no littoral for human habitation. To the Eskimo living north of Melville Bay there were two land masses, North Greenland and Ellesmere Island, which is still known to them as Akilineq, or The Other Island.

The Oxford University Ellesmere Land Expedition was on a larger scale than other expeditions sent out by the Oxford University Exploration Club, and that it started at all with the small initial resources of the subscriptions of the five members is due to the great ability and the enormous amount of work put in by Shackleton. Details of the organization will be dealt with by the organizer himself.

The expedition left St. Katherine's Dock on July 17 in the M/V *Signalhorn*, a Norwegian sealer of 100 tons gross, which had been chartered for the purpose. Food was taken for two years in case it should be impossible to relieve the expedition in 1935. Survey instruments had been lent by the Royal Geographical Society and collecting material by the British Museum (Natural History). A wireless transmitter had been lent us by the Air Ministry. We were equipped with Nansen sledges for ice-cap travel and material for building Eskimo sledges for travel on sea-ice. We had ample equipment in the way of clothes and tentage, and a two-storied winter hut, 18 feet by 12 feet, was to be waiting for us in sections at Godhavn. Dog pemmican was taken with us and this was to be supplemented by dried fish which we were to take on board at Greenland ports. Our Eskimo dogs we should also take on board in Greenland. The *Signalhorn* encountered heavy weather in the North Sea. It was necessary to keep head on into the wind to avoid the loss of deck cargo, some of which was damaged. By August 4 we were off Holsteinsborg in a thick mist and for the first time since leaving Scotland saw land, a rock awash,

which we only just avoided. As the Captain considered that it was impossible to reach Holsteinsborg while the mist held, we made for Godhavn, which we reached next day. Here we found our hut which was to be our winter quarters unless we wintered at the abandoned police station at Bache. Stallworthy was kept very busy bartering with the natives for such equipment as dog-lines, dog-whips, and dog-harness; and selecting the dogs. On the 6th we left for Jakobshavn where we took on board dogs and dried fish. Returning to Godhavn we shipped the hut, dogs, and more dried fish, and left on the 8th with seventy-one dogs and as much dog food as the Captain would allow us to take on board. We reached Thule on the 11th and left the same day, reaching Robertson Bay on the 12th. Here we received telegraphic permission to take with us two Eskimo and their wives who were known to Stallworthy, in place of the natives who had been detailed to us by the Danes. The Eskimo were Nukapinguaq and his wife Enilungwa and Inuatuk and his wife Natuk. While at Siorapaluk, the village in Robertson Bay, we were able to trade for further equipment. We also made a cache of food and ammunition, as it was at this time our plan to await here the relief ship which should fetch us in the summer of 1935. While these arrangements were in progress we gave a party on board to the children of Siorapaluk. Quite small boys came out in their kayaks and clambered aboard without assistance. The girls were brought out in our whaleboat. We entertained them with biscuits, sweets, and the gramophone. The children had perfect manners and were entirely at their ease. The bigger children looked after the smaller ones to see that they had their full share of the entertainment.

We left Robertson Bay early on August 13 on our first objective, which was to reach as far north as possible on the Ellesmere Island coast, and there establish winter quarters. Our hope was to reach Fort Conger, which would be an ideal base for the exploration of Grant Land which, of the four peninsulas of Ellesmere Island, appealed to us most. We already knew that the ice conditions this year were abnormal. Wordie had failed to pass the ice of Melville Bay, and Bartlett had been similarly frustrated. While pushing through the ice floes we took the opportunity of hunting such walrus as we encountered, and killed and took aboard seven. That evening we sighted Ellesmere Island. The next day we reached pack-ice which blocked Smith Sound. We made a landing near Cape Hatherton, and left a cache of food and ammunition, and also killed an additional walrus. Our inability to penetrate into Kane Basin was a great disappointment to us. We had hoped to establish our base at Fort Conger, or at worst to make winter quarters at the abandoned police station on Bache Peninsula. We hoped now to be landed on the coast of Ellesmere Island somewhere within reach of Bache; however our Captain, fearing that the pack-ice would break up and come south, made for Etah, where we waited until the 17th, when he agreed to make another attempt to penetrate Smith Sound or, alternatively, to land us on the coast of Ellesmere Island. We found the pack still unbroken but now extending south of the cove near Cape Hatherton where we had made our cache. The Captain abandoned the attempt to reach Ellesmere Island and returned to Etah. He now told us that he would make no further attempt to get north and that unless we were willing to be landed at Etah he must immediately

go south; further, that if the pack broke up he must immediately start south lest he should be shut in Foulke Fjord for the winter. In these circumstances we decided to make winter quarters where we were, and the next five days were spent in landing our equipment and stores.

On August 22 the *Signalhorn* moved slowly from her moorings opposite Etah towards the mouth of Foulke Fjord. We were meanwhile rowing ashore in the whaleboat with our last load. As the noise of our oars began to drown the sound of the *Signalhorn's* engine we suddenly heard the ship's siren; Captain With was morsing us a farewell message. The weather was perfect. It was warm enough to sun-bathe. There was however urgent work before us. Seventy tons of equipment and stores had been landed below spring-tide high-water mark. Cases with contents 100 lb. and hundredweight sacks of coal were to be carried up a steep bank. Timber for the hut had yet to be sorted and carried to the site for winter quarters. Caches would have to be made of the walrus meat and dried fish, to protect it from the Eskimo's dogs which had been turned loose on the mainland. These things we considered as we rowed ashore. After pitching tents in case the weather should suddenly break, we were busy manhandling the stores and equipment up a steep 25-ft. bank to the site of the camp, a piece of nearly level ground where was the site of the deserted Eskimo village and of Borup Lodge of MacMillan's 1913–17 expedition. As soon as the timber was brought up and sorted out the actual erection of the hut on part of the site of MacMillan's Lodge was undertaken by Stallworthy with Bentham as chief assistant. Haig-Thomas and Moore, with the assistance of Inuatuk, were now busy making trips by boat for the purpose of hunting walrus and making caches as far north as possible. Meanwhile Shackleton was sorting out the stores and equipment and the writer was collecting such plants as were still in flower. Later all members of the expedition were available for the hunting and cache-laying trips. Altogether some ten walrus and a number of seal were killed and cached whence the meat could be fetched by sledge in the winter. A large cache of human and dog food was made at a point known to us as Cache Point, a little north of Cairn Point. The pack-ice remained firm in Smith Sound and prevented us from getting into Kane Basin. For these trips we used a whaleboat with inboard motor and a small dory with outboard motor. The journeys were not without incident. Twice a boat was charged by a walrus, which was shot at close range, and on one occasion Shackleton and Moore were obliged to lift the dory on to a floe on which they drifted for eighteen hours.

At the beginning of October we made our last boat trip. The fjord was quickly freezing up. We had been greatly handicapped by the terrific winds which for days on end had prevented us from using the boats. We were, moreover, discovering the unsuitability of Etah for winter quarters. Walrus do not now visit the fjord and there are few seal. Large land game have long ago been exterminated in the neighbourhood. Our dogs had been landed from the *Signalhorn* on a small island in the fjord, known to us as Dog Island. This was necessary to prevent them from damaging our equipment before the hut and store had been completed. Unfortunately the strong winds had prevented us from getting to the island regularly by boat to feed them. Moreover they were so wild that when we landed with food many ran away and

could not be fed. Some had died or were killed by the other dogs and we found only their skulls. As the fjord began to freeze over, ice floes drifted against the island and when, by a change in the wind, the floes were blown away from the island, dogs were liable to be taken adrift. On one occasion we were able to row out and rescue four dogs from a floe. It is possible that on other occasions dogs drifted out to sea and were not recovered.

As soon as it was no longer possible to continue our cache-laying boat trips, we made dog-lines and harness and fetched the dogs from the island. On our last trip to Dog Island, on October 8, the sea was freezing so quickly that we got stuck in the ice on the way back. We had got wet to the thighs on the way back and at one time it seemed certain that we should have to stay in the boat until the ice was thick enough for us to walk ashore; however after several hours' hard work we were able to break a lane in the ice and reach the mainland. When the fjord was frozen over the remaining dogs from Dog Island came over to the mainland. One could not be caught and was shot. We now had fifty-five dogs from our original seventy-one. These were divided among the six of us and they soon became docile and got to know their individual masters. We each of us now had a dog team and practised dog-driving on the frozen fjord. It took us a long time to get our teams together and to learn the art of dog-driving; it was especially difficult to acquire the knack of using the 30-foot dog whip. We found the Nansen sledges ideal on fjord ice as they would have been on ice-cap, but that they would not stand up to rough sea-ice. We found later that the Victoria ash, which we had brought for the runners of the sledges which the Eskimo built for us, was very heavy and that for these a team of about fifteen dogs would be necessary. Our dogs were now reduced to forty-seven, as during the winter we had had some deaths from poisoning from dried shark flesh. In these circumstances we reduced our teams to three. The tedium of the winter was largely relieved by our wireless. We were able to get messages sent from Pittsburg and from Winnipeg, and we heard wireless programmes broadcast both from England and from America. A Christmas greeting from the B.B.C. we did not hear, but we got a message and a special selection of dance tunes played for us.

Early in November Stallworthy, the Eskimo, and I had twice attempted to reach Robertson Bay by the ice-cap, but on each occasion the attempt had failed because of blizzards. For a long time after these attempts we had been waiting for the ice to form beyond the fjord so that we could travel by sea-ice to Robertson Bay or Thule, but as soon as the ice formed, and before it was strong enough to bear the weight of sledges, it was broken up by the Etah winds. The Eskimo do not care to travel by ice-cap and wished to wait until it might be possible to do the journey by the coast. Fearing however that further delay might affect the date of our first journey north, I persuaded the natives to make another attempt by the ice-cap, and a start was made on January 28 by Haig-Thomas, the two Eskimo, and myself, with two sledges and dog teams. The weather was perfect and we got up the glacier without difficulty and travelled across the ice-cap until dark. We then built two small iglus, in which we spent the night. Next day we continued across the ice-cap and down a broad glacier to Neke, where is one Eskimo family, probably the most northerly family in the world. On continuing our journey in the dark

we were accompanied by Eskimo on two sledges returning from Neke to Robertson Bay, which we reached at 11 p.m., and slept in a native iglu. We had left a store of food at Robertson Bay on our way to Etah last year and were able to barter for dog food and equipment. We stayed another night here and left in the early afternoon with three natives with their sledges and teams, one native having with him a small boy whom he was taking to Thule to be treated for tuberculosis. The next part of our journey lay along the coast. After the daylight had gone we had a wonderful display of northern lights until we reached the village of Kanaq in the evening. Sleeping again in a native iglu, we started early and ascended a glacier. We left the ice-cap by a steep valley nearly free from snow, the Eskimo showing great skill in guiding the sledges so as to avoid rocks. The valley led to a fjord, which we followed to the sea. Here we found that my sledge had been damaged, but a native who was hunting seal took over my sledge and lent his own. We travelled on through the night, reaching Thule at 3 a.m.

During our stay there the natives were busy making for the expedition additional sheepskin-lined seal-skin mitts and kamiks, and dog-harness. Also we were able to buy *uksuk* (*phoca barbata*) thong for making dog-lines, lash-lines and whips. We had ordered similar equipment at Siorapaluk, the settlement at Robertson Bay, to be made as soon as permission was received from the Governor at Thule; this permission had been sent in a letter taken back by Nukapinguaq who had returned immediately from Thule with instructions to bring his wife, who was tubercular, for treatment in the Thule hospital. The delay would give the natives at Siorapaluk time to make the equipment. Several times while at Thule I had spoken by wireless to Etah, and listened for a reply in morse but had heard nothing. By February 14 no reply had been received to the Governor's cable to Copenhagen, so we decided to start back to Etah on the morrow. The Arctic winter was now over, the sun was above the horizon though not visible from Thule. The next day we set off heavily laden with stuff we had bought in Thule. We were seen off by the entire station and left it with great regret, though anxious to be back at Etah as soon as possible. Although no reply had been received from Copenhagen the Governor made the concession that it would be sufficient if we brought our Eskimo back by the end of May to any part of Greenland south of the Humboldt glacier. He also gave us permission to arrange with the natives at Kanaq, Siorapaluk, and Neke to help us on our journey north from Etah. Already, as we left Thule on February 15, the hills were rose-tinted, and soon afterwards we experienced the greatest thrill of the Arctic year, the first glimpse of the sun, flaming above the horizon and crimsoning the entire landscape. But the coldest part of the year was not necessarily over; often in the Arctic the lowest temperatures are experienced after the return of the sun. Returning to Etah we were a party of four sledges: besides Haig-Thomas's and my sledges we were accompanied by two native sledges. That evening we reached the glacier where is the first land crossing. Here was the iglu we had built on the way out from Etah. The natives now built a second iglu and here we stopped the night and all next day, as the Eskimo said there was a storm on the ice-cap. We continued our journey at 1 p.m. on the 17th and reached Kanaq at 5 a.m. the next day. We stayed in a native

iglu and left at 1 p.m. next day, reaching Siorapaluk at 9 p.m. that evening. We stayed the night with Enoq, who has a small store, certainly the most northerly store in the New World. We found that the letter from the Governor giving permission for the equipment to be made for us had not reached Enoq and that for this reason the Eskimo women had not started working on the equipment. Enoq however took our word that permission had been granted and the work was put in hand at once. At Thule I had had a cable telling us that we should be relieved at Etah. The cache we had made the previous summer was thus conveniently available for paying for the equipment being made for us. The day after our arrival here we moved to an empty iglu so that we could do our bartering without disturbing Enoq. We also arranged with Eskimo, as we had done at Kanaq, to help us on our northern journey. Some would travel with us to Etah and others would follow. The next day, collecting such kit as was ready, we continued on our journey, reaching Neke at 1 a.m. on February 21. The Governor at Thule had given us permission to engage, as permanently employed native in place of Nukapinguaq, Apilaq; and he and his wife and child, also Kokochea and his wife, joined us and we continued our journey the same day. On the ice-cap we ran into a blizzard which made travel impossible. The force of the wind was so great that it was quite impossible to build an iglu. The natives thereupon dug a hole in the ice-cap and from it carved out two caves, into which we crowded. This took two and a half hours, by the end of which time Haig-Thomas and I were very cold as our fur clothes were packed on the sledges and the wind was so strong that it would have needed several people to unpack the sledges without some of the things being blown away. Our ice cave was $6\frac{1}{2}$ feet square and 4 feet high and held six of us. Here we remained stormbound for three days, completing our journey to Etah on February 24.

This was about the time we had hoped to get off on our preliminary cache-laying trip, but many disappointments were in store for us. Of the three Greenland sledges for which we had material, two were unfinished and the third unstarted. There were a number of other things to be done, but none which might not be completed before the sledges could be finished. Inuatuk went sick as soon as we returned and also had an injured hand; and at one time said he was unable to go north at all. Apilaq, our other permanently employed native, also became ill and decided that even when well enough he could not go north. His sickness turned out to be lobular pneumonia, and after he recovered he returned home. Apilaq's place had to be filled. Porsman, who had come with us from Thule, volunteered for the post and we managed to get a letter through to the Governor at Thule and he wirelessed us the necessary permission. While Haig-Thomas and I had been away, the last of the walrus meat had been brought in from the caches. Owing to the unusually open season it had been impossible earlier in the year to reach some of these. The caches yielded less dog-feed than we had expected. Some had been entered by foxes and one had been opened first by a polar bear. Half a cache had been used by Nukapinguaq who, on leaving Etah, instead of taking his wife to hospital, camped on the coast south of Etah, where he hunted walrus. Being unsuccessful in this and being without dog-feed he had used our cached meat. Before the end of February all dog-feed except pemmican was finished.

During March we had a fluctuating number of Eskimo at Etah. These were chiefly the hunters who had come in response to the arrangements we had made and who intended to go north with us. There had however been in their villages a shortage of dog-feed during the winter and the hunters were unwilling to start before they had got their dogs in better condition. We gave the natives pemmican for their dogs, but this was considered unsuitable for enabling the animals to put on weight and the Eskimo, after failing to get walrus locally, returned to their villages. They expected to be able to hunt walrus farther south and promised to return as soon as their dogs were in better condition. With the idea of also fattening up some of our dogs Moore went with some of the Eskimo, himself driving a team of twenty-one dogs. Two out of our three dog-teams were taken, but it was found that the same shortage prevailed in the villages and Moore returned with the next lot of natives coming to Etah, the dogs returning thinner than they had been before the journey.

As the natives returned to Etah we were once again very busy providing for their various requirements: cooking for them on arrival, issuing them food, or nursing the sick. We however got the men to work on the sledges, which were finished on March 17. This was a month later than we had hoped to get off and another relay trip to Cache Point was still necessary. We had during the winter been cut off from our cache by the absence of continuous ice-foot. There had moreover been little snow locally and the Eskimo had considered up till now that it would not be possible to take heavily laden sledges overland. Had we been able in the autumn to establish a cache at Cape Jackson we could have reached the cache, at any time in winter when there was a moon, by the ice-cap; but our cache as established was far from any glacier and so could not be reached from the ice-cap. Handicapped as we were by these circumstances we considered it worth while postponing our journey for another fortnight if necessary for getting the help of the hunters, instead of starting at once with only our two permanently employed natives, especially as they would have started, in the circumstances, unwillingly. Owing to the lateness of our start and to the fact that our cache was such a little way north of us it would be necessary to rely largely on seal, which do not lie on the ice much before the middle of April or May. For this reason it was important to split up into three parties. A large party would be unable to support itself by hunting. The number of Eskimo at Etah varied from day to day and the proportion of those who were willing to go north with us varied almost hour by hour. On March 18 there were five Eskimo who, though not willing to go north on the big trail until the end of the month, would help us on a relay journey overland to Cache Point, and this day was spent "packing" our loads 800 feet up the hill behind our winter quarters. The next day at about noon we started off. All the dogs were harnessed to each of the sledges in turn and they were so taken to where we had carried the loads the day before. The land crossing turned out to be a hard journey, as there was little snow and it was necessary to assist the dogs by pushing the sledges the whole way to the divide. Shackleton's and my team was so overloaded that when we reached the divide the dogs' and our combined efforts failed to move the sledge and we had to unload and "pack" the loads over the ridge. Beyond the

divide it would be easy going downhill. Just as we were ready to start again an Eskimo returned to say that they and Moore and Haig-Thomas had reached the sea with their sledges but found that the condition of the ice made it impossible to travel farther. They had all left their loads on the coast and were returning. At this moment Bentham and Stallworthy caught us up. They had had an accident to their sledge which had fallen 15 feet, turning upside-down and breaking the sledge handles. Luckily they had themselves fallen clear of the sledge. We now left our loads at the top of the snow slope and as soon as the others returned up the hill we went back to Etah. We were rather depressed by the journey. We were exhausted by pushing the sledges and we were cut off from our cache. We had discovered that the sledges were much too heavy; on sledges half the weight we could have loaded as much as the dogs could pull. The weight was partly due to their unnecessary length and partly to the weight of the runners of Victoria ash. Soon after this journey other Eskimo went south to their villages. By the last to go we sent a message that we were definitely going north at the beginning of April and all who were going with us must be at Etah by the last day in March. At 2.30 a.m. on March 30 eight sledges arrived, with seventeen Eskimo and Dr. Holm, who had come from the hospital at Thule and was visiting outlying villages. The Eskimo included some who were willing to go north with us, and two more arrived the next day. We now had a population of thirty-two at Etah, as some of the Eskimo had brought their families. Besides our two permanently employed Eskimo, Inuatuk and Porsman, ten hunters were now found willing to go with us, and these included Nukapinguaq, whose knowledge of Grant Land was likely to be invaluable.

During our journey out to Greenland our plan had been to winter on the east coast of Ellesmere Island as far north as possible. At best we were to winter at Fort Conger, in Grant Land; at worst we should winter at the abandoned police station in Grinnell Land. Before establishing our winter quarters we should have unloaded from the *Signalhorn* a store of food and paraffin at Robertson Bay, where we expected to await the relief ship on the completion of our explorations. Our first disappointment at having to winter at Etah was somewhat modified as we learnt more of the conditions of travel in this part of the Arctic. Ice conditions for sledging north from Smith Sound are better along the Greenland than along the Ellesmere Island ice-foot. This is due to the prevailing wind which piles up the ice against the Ellesmere Island coast, and also to a heavier snowfall on that side of Kane Basin. Had we wintered at Bache we should probably yet have found our best route to be by the Greenland ice-foot. Also our return journey from the north in the spring would have to be down the Greenland coast if we wished to stay north as long as possible, as, were we to return *via* Bache, the danger of an early break-up of the ice in Smith Sound would necessitate a comparatively early return. Moreover wintering at Bache and travelling to Robertson Bay after our spring journeys would mean abandoning at Bache much of our equipment, whereas in our present circumstances we could await the relief ship at our winter quarters and put on board everything that was worth taking home, including our autumn collections. By following exactly the same route on our return journey as on our outward journey from winter quarters we could

leave caches of food, paraffin, ammunition, and photographic material, which would speed-up our southward trip.

Our objective was the exploration of the interior of Grant Land, Grinnell Land, or Ellesmere Land. At Etah we were within easy striking distance of the last two but depressingly far from Grant Land, which was our preferred objective. As the ice did not break up in Smith Sound in 1934 our boat journeys had not enabled us to make caches farther north. Terrific winds in the winter and the nature of the coast had prevented an ice-foot forming at the mouth of Foulke Fjord, and we were thus prevented from sledging north along the coast during the winter and the small snowfall had prevented sledging overland to the pack-ice. Retaining Grant Land as our preferred objective we, during the winter, considered alternative routes to that along the Greenland coast, known to us as the sea route. This route had the advantages that, in being much better known, there was much less likelihood of unforeseen difficulties; that there is usually open water at Cape Jackson where seal could be caught at any time in the sledging season; and that it would be possible to catch fish at any time in Lake Hazen. The Eskimo however preferred a route across Smith Sound, up Flagler Fjord, across the isthmus between Grinnell Land and Ellesmere Land, and then by ice-foot and fjord ice to Western Grant Land. This route, known to us as the land route, had many advantages. According to the Eskimo there was more game on the west of Ellesmere Island. The route is shorter. We should reach the west of Grant Land, the interior of which is entirely unknown, instead of the south-east of Grant Land which is the only part of the interior of Ellesmere Island which was already explored. Our geologist considered that this route would provide the best field for his work. According to the Eskimo and to Stallworthy, our technical adviser, it would be inadvisable for any of the members of the expedition to travel without Eskimo on sea-ice in the spring, and it would be necessary, if we went by the sea route, for the eight of us with our five sledges to keep together, unless some were to return early along a coast already known, where little useful work could be done. By the land route we should have advanced bases at Bache and Fram Haven, where there were shelter, food, fuel, and ammunition. It would be possible for the whole party to cross to Western Ellesmere Island and then for picked teams to go on to Grant Land. The support parties could then retire on Bache and could use the station as a base for the exploration of the interiors of Grinnell Land and Ellesmere Land, without going over sea-ice, and could there await the return of the Grant Land party so that the whole expedition could cross Smith Sound together at the end of the trips. Certain modifications of the land routes were considered. If we could cross the Grinnell Land ice-cap to Greely Fjord from Dobbin Bay, or some other bay in the neighbourhood, we should be passing through unknown country and should still further reduce the length of our route. The Eskimo have an ingrained aversion to travel by ice-cap, but considered the project feasible. They estimated that owing to the bad ice conditions of that part of the Ellesmere Island coast it would take six days to get from Bache to Dobbin Bay, and that it would take eight days to cross the Grinnell Land ice-cap. An alternative modification was to cross Grinnell Land from one of the glaciers at the head of Princess Marie Fjord to Cañon Fjord. From information

Haig-Thomas and I got from natives at Siorapaluk this crossing had actually been made by Eskimo. Such a crossing would be less direct than that considered from Dobbin Bay and would pass through partially known country, but it would be more likely to be easy to accomplish.

On these considerations and on the assumption that we should have the assistance of not more than two Eskimo our plan, as decided on for the spring, had been that as soon as the ice-foot formed or there was enough snow for a land crossing to Cache Point we should take the rest of our necessary stores to our main cache and as soon after the middle of February as possible cross altogether to Bache. It would not be possible to take all the loads across Smith Sound in one journey, so while the main party was returning to bring across further loads a small party would reconnoitre to find out the possibilities of a crossing by the Grinnell Land ice-cap. As soon as the expedition was once again together a crossing would be made to the west coast of the island. Further plans would depend on the amount of game on the west coast. If it were plentiful the whole expedition would travel to Grant Land and there break up into three parties. If there should be a shortage of game two parties would be in support and return to Bache whence they could do exploratory and geological work until the return of the Grant Land party, when the whole of the expedition would cross Smith Sound together. Now that we had twelve Eskimo to help us we could at any time split up into three parties. The advantages of this had all along been obvious to us. We should cover more ground and move more quickly: and being partly dependent on game, a small party would be at an advantage over a large party. Early in the expedition, before we had considered the land route, when we found that we had only enough dogs for three teams, Bentham's and Stallworthy's teams had been joined, Moore's and Haig-Thomas's, and Shackleton's and Humphreys's. This was with the idea that we should be operating in three parties in Grant Land. The geologist would not be operating so far from the advanced base as the others and with the assistance of Stallworthy's experience could dispense with the help of the Eskimo; the two surveyors with one Eskimo would work together, while the other two members of the expedition would make rapid journeys with the other Eskimo. But the expedition was now rearranged. Moore and Stallworthy were to attempt the exploration of Grant Land, making if possible a crossing as near the centre as possible. Shackleton and Bentham formed the geological party. The third party was to attempt the exploration of the interior of Grinnell Land and Ellesmere Land. The chief advantages of the land route over the sea route had now disappeared and routes were left to each party to decide for itself. The best dog team, which had been Bentham's and Stallworthy's, was detailed to the Grant Land party; the second best, that of Shackleton and Humphreys, went to the geological party, and the remaining team to the Grinnell Land party.

Journey to Bache

In one way our party was handicapped by having no permanently employed native. We had however, in addition to Utah and Kokachingwa, who were to return as soon as the five sledge loads were reduced to three, two hunters who promised to stay with us until the end of May. These were Kuchiketo

and Kokochea. All April 1 was spent in preparing for the journey. We took two pyramid tents, one of which was to be sent back later with the support men. These tents had been left erected experimentally for a long time in the autumn and afterwards strengthened where they tore. The strengthened tents were entirely satisfactory. They were lighter, warmer, and stronger than other tents of the same size, and quicker to erect or strike. In the apex of the tent, above the circular entrance, the heat from the stove collected sufficiently to dry our clothes while we cooked our evening meal. We gave the Eskimo all the clothes and sleeping-bags they wanted. Haig-Thomas and I took each a heavy and light sleeping-bag, five pairs of seal-skin boots with detachable sheep-skin linings, and three pairs of seal-skin mitts, similarly lined. Actually during the trip I only used one pair of seal-skin boots as it was always possible to dry the linings at night. We each had a set of woollen underclothes with a set in reserve. Haig-Thomas had breeches of polar bear-skin and I of moleskin cloth with Grenfell cloth trousers as well, though I seldom wore them. We each had a Mackinaw shirt and over that Haig-Thomas wore a sweater and a moleskin cloth parka with duffle lining, and I a couple of sweaters and a Grenfell parka. It was seldom necessary to wear all these clothes, and we were never cold during the journey. We took with us in addition reindeer-skin parkas, trousers, and overshoes, but these were unnecessary and we soon discarded them. As the only chronometer and portable wireless set were with the geological and survey party, and as we were intending to cover as much ground as possible, we reduced survey instruments to one prismatic compass. We had exchanged with Utah our heavy sledge for a small one of soft wood which was much lighter and was big enough to take all that our team of dogs could pull. We got off on April 2 and were the first party away from Etah, Shackleton and Bentham volunteering to stay and tidy up the camp after the other teams had left. Shackleton was also busy distributing food for the use of the Eskimo women and children until the return of the hunters.

Our sledge and loads were already at the top of the hill, but the sledges of the Eskimo were at Etah and they started by a different route. From the top of the hill we followed what was now known to us as the "pemmican" trail. Near the divide we had a mishap which might have been serious. Driving down a steep snow slope the dogs got out of control. They headed straight for a slope which was nearly precipitous, and they could not be stopped. At the last moment Haig-Thomas and I rolled off the sledge. It seemed inevitable that the sledge would go over the edge, but at the last moment the dogs swerved and stopped. The sledge swung sideways and came to rest within a foot of destruction. Soon after we had continued our journey we were overtaken by the Eskimo. Just beyond the divide, at the top of the long snow slope, were some of the loads left on the "pemmican" trip, others having already been taken forward by Inuatuk. After taking the remaining loads on our sledges the Eskimo helped us down the slope. The slope was so steep that even with a man hanging on to the handles of the sledge and so acting as a brake the sledge would travel faster than the dogs could gallop. In such cases the dogs have to be whipped to one side so that the sledge shoots past them and they are dragged behind as an additional brake. At the coast just beyond the foot of the slope

were the rest of the loads which had been taken there on the "pemmican" trip. Here we had tea and rested the dogs. We continued our journey by sea-ice to the cache in Hatherton Bay which we had established from the *Signalhorn* last autumn. Here we built a snow iglu for the night. This was the only iglu built during the trip, as the Eskimo preferred the pyramid tent. The next day we travelled by ice-foot to our main cache at Cache Point. At two places the ice-foot was covered with hummocks and here a great deal of chopping was necessary and took several hours of very hard work, at which the Eskimo showed amazing skill. But for the fact that the other two parties would be able to use the way we had made, it would have been better to have passed these points by a détour inland. During this part of the journey we passed the site of the first cache laid in the autumn, afterwards transferred farther north. Here we found a sledge-box of provisions which we took along with us. We also passed the last cache made in the autumn, but our loads were as much as we could carry and we left the contents for the other parties. We reached the main cache at Cache Point at 8.30, and there camped.

We were up at 4.30 and found that Moore's party had arrived during the night. The next day was spent in preparing for the crossing to Ellesmere Island. Haig-Thomas and the Eskimo opened all the boxes of dog-pemmican in the cache, while I filed the runners of our sledge. Later the natives filed their runners and Utah mended his sledge. In the afternoon Moore and I counted the tins of dog-pemmican. There were eighty-four and a half tins of 48 lb. each. Haig-Thomas and I took twenty-seven of these and the Grant Land party left the same number for the geological party. There was a shortage of cooking pots and ammunition, so the Grant Land party took what they required, and we arranged to draw what we should need from the abandoned police stations at Fram Haven or Bache Peninsula. We were up next day at 6.30 and off at 8.30. We first travelled north on sea-ice and then west towards Pim Island. The ice conditions were good. We stopped four times to hunt seal at their breathing holes and two were shot. We passed bear tracks but they were all old. We camped on sea-ice and next day continued our journey towards Pim Island. More bear tracks were seen but all were old, except in one place where the footprints had been made the day before. The conditions remained good until we got near the coast of Ellesmere Land. Here were pressure ridges which made travel difficult, so we left some of our loads on the sea-ice and travelled to Fram Haven lightly loaded. Here next day we drew stores, made a list of what we had taken, replaced the boxes, and returned to our loads beyond the pressure ridges. Packing the loads on to the sledges we travelled towards Cape Camperdown, off which we camped on sea-ice. The ice conditions were bad because of the pressure ridges and the deep snow between them. No seal holes were seen, but many bear tracks, mostly old. The next day we travelled slowly over the pressure ridges to the ice-foot where we left most of our loads and then had an easy run along the ice-foot to Bache Police Station. From the station next day Haig-Thomas went with some of the Eskimo to shoot seal in a patch of open water in Flagler Fjord. Meanwhile I polished the runners of our sledge and two Eskimo re-made a sledge from material found at the station. Utah, who was much older than the other natives, rested all day. In the afternoon the geological

party arrived. In the evening the hunters came in with six seal, of which Haig-Thomas had shot five, and a hare. We were unable to get the Eskimo to start next day, so Haig-Thomas went off again with Eskimo to hunt seal in Flagler Fjord. They took an iceboat from the station and floated it, but most of the open water of yesterday was now covered with mush ice which the boat could not penetrate and only one seal was bagged. Meanwhile I went inland with Bentham, who was geologizing.

Grinnell Land Trip

The next day in the afternoon we got off and travelled easily along the ice-foot to our cache at Cape Camperdown, passing on the way many fresh bear tracks. The weather was so mild the following day that we decided to leave here our reindeer clothes and second sleeping-bags and to reduce our seal-skin boots to three pairs each. This day's journey took us past Cape Albert, a magnificent headland looking like a Norman castle. Beyond this we passed the remains of a landslide. Enormous boulders had bounded over the hummocks and lay on the sea-ice 50 yards from the ice-foot. We followed the ice-foot past Cape Henry and up a fjord known as Bartlett Bay, crossing it to the ice-foot on the other side. At Victoria Head we camped, the Eskimo going off to hunt seal unsuccessfully. Our first objective was to attempt a crossing of Grinnell Land ice-cap from one of the bays just north of the entrance of Princess Marie Bay. The next morning we made for our return journey a cache of paraffin, human pemmican, biscuits, and tea, and crossed the bay, passing just south-west of Norman Lockyer Island, and camped at a cape on the west coast of Franklin Pierce Bay just north of that island. Leaving the other Eskimo to make camp, Haig-Thomas, Kuchiketo, and I drove on along the ice-foot to the valley at the head of the bay. The Admiralty Chart shows a glacier from the main ice-cap of Grinnell Land terminating in this valley. Driving up the valley we soon got into deep soft snow, which got deeper as we advanced. Eventually we could take the sledges no farther and we went on foot. We were now in unexplored country. We made our way slowly up the valley, the snow becoming thigh, and then waist deep. We found recent tracks and fresh dung of musk ox. This was interesting as in this part of Ellesmere Island musk ox were believed to have been exterminated. Midnight found us still plodding up the valley. Near the head of the valley we climbed a cliff in order to get a view northwards. There was no glacier within sight. We now returned, reaching camp at 4 a.m., and the next day, keeping to the ice-foot, we rounded Cape Harrison and reached a small bay at the mouth of Copes Bay, opposite Cape Field. Here we left the ice-foot and went on to the sea-ice, where however travelling was slow as there was deep snow. Farther on we were able to return to the ice-foot where travel was easy. We camped on the ice-foot and next day reached Parrish Glacier at the head of the fjord. Here was glare ice and the glacier itself was almost free from snow. The Eskimo were unwilling to travel farther this day as they expected a blizzard, so we camped. Haig-Thomas that evening went with the Eskimo up a hill on the west of the glacier to choose a route for the next day while I collected rocks along the coast.

The next day we decided that the supporting natives, Utah and Kokachingwa,

The "Signalhorn" in loose pack

Robertson Bay, N.W. Greenland

Abandoned police detachment at Bache Peninsula

Good ice-foot on E. coast of Ellesmere Land

should return. We could carry on three sledges all that we should need for the attempted crossing of the ice-cap. We divided up our loads: part was to go with us; part was to return with Utah and Kokachingwa, and part was to remain at the foot of the glacier. This last included much of the dog-pemmican in order to lighten the sledges and because the Eskimo thought that should we get across we should find plenty of game in Greely Fjord. Early in the afternoon we drove without difficulty straight up the glacier. The glacier had just enough snow to make the surface nearly perfect, but the slope was steep and the dogs got tired, so, nearly at the top of the glacier, we left six tins of pemmican behind and these were fetched later on by the Eskimo while we were pitching camp. It was a warm though windy night, but next day was misty and calm. The natives would not travel this day because it was misty and they expected the wind to return. The next day was also calm and the visibility good, but in the morning the natives were still unwilling to travel. We were camped in unexplored country and were now able to get a view into the unknown interior. To the east high cliffs shut out any extended view. Some miles north of us were mountains, but on each side of them, and also to the south-west, the ice-cap continued to an unbroken horizon. To the west were cliffs and at a distance, estimated at 50 miles, was a single high conical peak, the bearing of which we took. The weather kept fine until noon, when the Eskimo agreed to go on. We started soon afterwards and travelled north towards the mountains ahead of us, hoping from them to set a compass course to Greely Fjord. Very soon after our start the snow began to get deep and soft. The runners sank deeply into the snow and it was very difficult to start the sledges again when they had stopped. After four and a half hours we camped, as the dogs were exhausted. The next day we spent five and a half hours pushing slowly northwards but made little progress. Eventually the dogs could drag the sledges no farther and we stopped. It was impossible to go farther and we returned in five hours to the foot of the glacier.

Our plan was now to attempt a crossing from one of the glaciers at the north of Princess Marie Bay to Cañon Fjord. We continued therefore from the foot of Parrish Glacier, crossed the isthmus of Cook Peninsula and camped on the east side of the bay south of the isthmus. The next day we travelled along the south-west coast of Cook Peninsula and halted at 5 p.m. to divide among the dogs and ourselves a seal which Kuchiketo had shot. This, on April 20, was the first we had shot lying on the ice. From now onwards seal should be easy to get. At this point on the coast were magnificent cliffs which we photographed. A little farther on we noted Eskimo tent rings on a gravel beach. On the chart a small island is shown just off the south-west cape of Cook Peninsula. We passed close to the position of the island as shown on the chart but saw no signs of it. On the other hand we saw a small high islet not marked on the chart, in the middle of Woodward Bay, just opposite the small bay south of the isthmus of Cook Peninsula. Crossing Princess Marie Bay we camped on the ice-foot of the northern coast of Bache Peninsula at a spot whence we hoped to photograph Woodward and Sawyer Bays the next day. Before going to bed we filed the runners which had got scored by crossing the isthmus. The next day it was snowing and photography was impossible. Sven Hedin and Benedict Glaciers appeared to offer easy access to the ice-cap,

but it seemed unlikely that the snow conditions would differ much from those we had encountered above Parrish Glacier. Travelling along the ice-foot we reached the isthmus of Bache Peninsula. The way across was not known to the natives and we got into deep snow. It was necessary to harness all the dogs to each sledge in turn until we got to the divide. Our loads were now sufficiently reduced for us to scrap one sledge, which we decided to do at the end of the run. Dropping down a cliff on to the ice-foot a runner of our sledge was broken. It could have been repaired, but this was not now necessary. We camped at our seafall.

Our next plan was to cross Ellesmere Island by the isthmus between Flagler and Bay Fjords, and then attempt a crossing of Grinnell Land to Cañon Fjord. The Eskimo agreed to this but insisted on first returning to Bache Station in order to dry their clothes, which had become soaked with sweat during the making of the land crossing, and to get a supply of seal meat as they had little confidence in our pemmican. We added our dogs to the native teams, Haig-Thomas travelling with Kokochea and I with Kuchiketo, and reached the station after an easy run.

The Ellesmere Land Trip

The open water in Flagler Fjord had been frozen over for some time and so the station was no longer a specially good base for hunting. Our Eskimo wished to stay a week, but we were anxious to get off as soon as they had dried their clothes. The geological party left the next day, but we were not able to get our Eskimo to start until two days later, when we made an easy run to our last camp where we had left most of our loads, and the tent standing. On the way Haig-Thomas and I went on one sledge and left the Eskimo, who were hunting hare, to follow on the other. The following day we drove to the head of the fjord in very strong wind over glare ice. The dogs found it very difficult to keep their footing and kept falling over, and the sledge was blown sideways when we were not going exactly into the wind. Near the head of the fjord we saw what looked like a small snowball alternately moving across the fjord and rolling at great speed down wind. An Eskimo grabbed it and it was not until he put it in my hand that I saw that it was a lemming (*Dicrostonyx*), the only one we saw on the trip. We put it back on the ice and it shot off down wind at great speed. That night we camped at about a third of the way across the isthmus. Near the camp we noticed recent musk ox tracks. As we continued next day along the valley we had several views of the Ellesmere Land ice-cap which was south of us, but none of the Grinnell Land ice-cap. At two places advancing glaciers reached the valley from the south, and just beyond the divide we reached the place where a large glacier from the south obtruded into the valley which was nearly choked with ice talus which had formed a lake, now frozen solid, above it. The Eskimo considered that it would be better to make a détour than to chop a way along the valley through the blocks of ice. While they were making tea Haig-Thomas and I walked most of the way along the face of the glacier. Nowhere did it actually block the valley and it seemed to us that a couple of hours' chopping would make it possible to take sledges through without unloading them. Returning to our sledges we harnessed all the dogs to each in turn and so reached a small valley running into the main

valley below the glacier. The way was mostly over rock with little or no snow, but in places there were steep snow slopes where the sledge had to be sent on ahead of the dogs. At a turn in a steep slope a runner of Kuchiketo's sledge split in two. After we had unloaded the sledge I went down to the main valley to find Kokochea who was ahead, and send him back to help to mend the sledge. I then unloaded his sledge to find the brace and bit which Haig-Thomas then took to the Eskimo. Finding that he could not help them he returned, and we waited until the repaired sledge was galloped downhill to us. The rest of the journey to Bay Fjord was easy, as the valley was nearly level. Just before reaching the sea we passed Thumb Mountain, which guards so strikingly the western portal of the land crossing. On reaching the coast we followed it west a short way and then camped.

The Eskimo would not now attempt the crossing to Cañon Fjord. They wished first to hunt bear or caribou so as to give the dogs plenty of fresh meat. There was likely to be more game farther south and they agreed to making a crossing of Ellesmere Land to Baumann Fjord. The western coast of this part of Ellesmere Island is very different from the east coast. In past times the western coast was thickly populated. The hills are low and in winter it is possible to drive inland almost anywhere. The ice-cap nowhere comes near the sea. There are large areas of undulating country, with vegetation which supports innumerable musk ox and caribou. The next day we followed the Ellesmere Land coast farther west. Everywhere on land were tracks of musk ox and caribou. We soon saw herds of musk ox on both sides of Bay Fjord. They varied in number from three or four to about a score and looked very conspicuous because of their intense blackness, contrasted with the light brown colour of the exposed rocks. A little farther on we saw herds of caribou as well as musk ox, and here we camped so that the Eskimo might hunt the caribou. The natives went off hunting that evening and returned during the night after a successful trip. Haig-Thomas and I had gone to bed but were roused by their return. They had been followed by an Arctic wolf, the only one seen by the expedition. It stopped about 350 yards from the camp. The visibility was bad as there was a mist, but Kuchiketo shot at it and hit it, as he thought, in the leg. It was however probably not badly hurt, as it ran off without limping. The next morning we saw a few drops of blood where it had been standing. In view of the number of caribou in western Ellesmere Land and Grinnell Land it is remarkable that wolves are not more common.

The natives now wanted to rest the dogs after a heavy feed of fresh meat, and it was not possible to go on again until two days later. Besides meat the Eskimo had brought back samples of coal and fossil wood. Haig-Thomas and I visited the places where these were found and collected further samples for the expedition geologist. The coal, as far as could be seen, appeared to occur as a vertical seam about 2 yards wide. Soon after the start of the next day's run we crossed fresh bear tracks and everything was turned off the sledges so that the Eskimo could follow the tracks quickly. We made camp and seven hours later the natives returned with the bear. There was now plenty of meat and the natives had a bearskin which is so valuable to them for making breeches and is the chief objective of their trips north at this time of year. Late that evening, after a sleep, we continued our journey, travelling by night and

camping next morning on the ice-foot opposite Gretha Islands. When we woke there was a strong wind and the natives would not travel that day. The next day however, May 4, we got off at 6 a.m. The evening before Haig-Thomas had walked inland and seen a valley due south of the coast, a little way west of us. The valley had appeared to offer easy access into the interior, but the Eskimo preferred to drive straight inland from our camp, cutting into the valley a little farther south. We had left everything possible behind, taking with us only the bare necessities for a three or four days' trip. The dogs were in very good condition after unlimited meat and a short rest. Even before we reached the valley we made good going although the snow was thin. This part of the journey was over what appeared to be a raised beach and which was strewn with clam shells. The ground was spotted with tufted vegetation such as grass, silene, saxifrage, and poppy. There were musk ox tracks everywhere and near the coast were musk ox skulls. In the valley the going was particularly good as there was sufficient hard snow. The valley was narrow and as we got farther from the coast it became narrower, and the cliffs limiting it higher. At the divide the cliffs were sheer or, in places, overhanging. At every twist in the valley one expected some obstruction, but everywhere the floor was covered with hard snow and our progress was not checked. A little beyond the divide the valley broadened out and as it was slightly downhill we could at times break into a gallop. Suddenly in the distance we saw a small herd of caribou. Kuchiketo and Haig-Thomas went on while Kokochea and I waited out of sight. After a few minutes we heard rifle shots and our dogs immediately broke into a gallop. On getting up to the herd Haig-Thomas and Kuchiketo had shot two or three of the caribou which, like all caribou we had seen in western Ellesmere Land, were very tame. The rest of the herd had then drawn off to a little distance away and then stopped. After hesitating for a bit they started to come back to their fallen companions. Kuchiketo thereupon shot the rest of the herd. We very soon cut up the meat, but a sudden rush by both dog teams accounted in a few minutes for one caribou and left the teams in an amazing tangle. After sorting out the teams and taking on board enough meat for a feed at the end of the crossing, we continued our journey.

We had started due south and later travelled roughly south-east. We now reached a place where the valley bifurcated, one part running uphill in a south-west direction and the other part, which we took, going due east downhill. Later our valley narrowed and became steeper. There was a good deal of débris strewn about the valley, including large lumps of coal. The valley now turned south-east and we dropped down on to an alluvial plain running nearly due south and appearing to be a fjord whence the waters had receded. The floor of the valley was a network of shallow frozen streams, the ice being covered with but a powdering of snow. We travelled for two or three hours along this plain which ended abruptly at the sea, the valley continuing as a fjord. Our crossing had taken sixteen and a half hours. The next day we wished to travel down the fjord, but the natives would not go any farther, fearing that a heavy fall of snow might make the return crossing difficult or impossible. A bearing taken down that part of the fjord which was visible showed it to run just east of south. A few miles away from us however the

fjord bent to the west and the cliffs on that side of it prevented a view of the mouth of the fjord and the open sea. Assuming that the coast-line of this part of Ellesmere Land is approximately correctly shown on the map, we had reached Vendom Fjord, which had been discovered by the Sverdrup Expedition but not explored to its head.[1] The position of our seafall as deduced from compass bearings, times, and estimated rate of travel, would indicate that the fjord extends several miles north of its position as shown on the chart. Next day we returned to Bay Fjord. On our way from the head of the valley to the divide we discovered some fossil-bearing rocks and stopped to collect some specimens for the expedition geologist. Near the divide we stopped again to take on board the remainder of the caribou meat. At the end of the journey we varied our route, reaching the sea without leaving the valley. The next day we collected our loads and also the bear skin from the next camp. Wishing to photograph musk oxen we stopped when we saw a small herd near the coast and walked inland with a couple of dogs with which to round them up. Only one dog would approach the herd but it was enough to make them bunch. As long as the dog remained near the herd the musk oxen kept in close formation except that one or another would occasionally grunt and make a short rush forward, afterwards reforming with the herd.

When returning from our crossing of Ellesmere Land our companions had promised that if no fresh snow had fallen while we had been away they would attempt the crossing of Grinnell Land from Bay Fjord to Cañon Fjord. This we were particularly anxious to do, partly because an ascent of Mount Moore might give a view into the interior of Grinnell Land and, if so, we should probably be able to get another bearing on to the high conical peak we had seen from the ice-cap. Our dogs were now in perfect condition and we had plenty of meat. There were caribou on the hills and seal asleep on the ice, but we did not need to hunt. The next day however the natives would no longer consider attempting the crossing to Cañon Fjord, nor would they contemplate going even as far as Mount Moore. They wished to return to their villages in Greenland lest an early break-up of the ice should cut them off from their homes. This was a disappointment as the ice and weather conditions were perfect for travel. However our own sledge was at Bache Isthmus, so in any case we must make the return land crossing to Flagler Fjord. The next day we travelled inland and reached the glacier obtruding into the valley from the Ellesmere Land ice-cap. The next morning we all "packed" stuff up to the top of the steep snow slope where the sledge had been broken on the outward journey. Haig-Thomas then walked along the valley and joined us beyond the détour. He found that the whole of the valley along the face of the glacier would be passable by sledges without too much chopping among the ice boulders which had fallen from the face of the glacier. We

[1] The map of the North West Territories issued by the Department of the Interior of the Government of Canada shows the distance from Gretha Islands to Vendom Fjord as 60 miles. Mr. Haig-Thomas believes that it is impossible that Dr. Humphreys and he should have accomplished this and the return journey, *i.e.* about 140 miles, allowing for deviations, over difficult country, with only one camp. He therefore thinks that the fjord reached was not Vendom but Trold Fjord : and he is supported in this belief by the Eskimo Nukapinguaq, who had previously made the same journey with Sergeant Joy, R.C.M.P.

camped that night at the head of Flagler Fjord and the next night reached Bache Station, where we found the geological party.

Visit to Haa Island

On May 12 we left Bache to visit Haa Island, where there are Eskimo remains which have never been investigated. We got off on the morrow and that night reached the island, where we spent two days. Haig-Thomas and I examined the village site while the natives hunted seal, of which there were now plenty lying on the ice. There were about fifteen house sites on the island. The ground was frozen hard and it was not possible to dig below the ground. One iglu however had the wall still standing and from the moss packed between the stones we found a number of artifacts which, if these walls were the most recent part of the settlement, showed that the village had not been occupied for about a hundred years. These are now in the Pitt-Rivers Museum at Oxford. Some graves were also examined. In one were the skeletons of a young girl and a baby. The Eskimo said that judging from the care with which the grave had been built her people must have loved her very much.

The Eskimo were unwilling to remain longer in Ellesmere Island, fearing lest an early break-up of the ice should prevent a return to their village of Kanaq, which was in the neighbourhood where Haig-Thomas had planned to do ornithological work in the spring. The geological party was also getting ready for a return to Greenland. The next morning we set out across Smith Sound. Camping once on the ice we reached the coast of Greenland just north of Cache Point at 1.30 a.m. on May 19 and continued south along the ice-foot. It was low tide and the ice-foot had been melted away below, so that it projected from the cliff like a shelf. Haig-Thomas and Kokochea were in front. They were rounding a small cape when suddenly a large piece of the ice-foot broke off under the front of the sledge and the dogs dropped from view, suspended by their lines. Haig-Thomas and Kokochea rolled off the sledge, Kokochea hanging on to the handles of the sledge to prevent it from being dragged into the sea by the weight of the dogs. Haig-Thomas ran to the assistance of Kokochea, who then cut the draw-line, letting the dogs fall into the water. By this time our sledge had arrived on the scene and we let Kokochea down by a line on to the floating piece of ice-foot, and drew up the living dogs one by one. Two dogs lay dead on the ice-pan, crushed by other bits of fallen ice; four others were not seen again. We camped here and went on the same evening. Our next camp was at the Pemmican Cache, where we found a snow iglu and part of a dog which the natives said Utah had stopped to eat on his way back. Here we left some of our loads, to be fetched later by boat. We then crossed by the "pemmican" trail to Etah. All was still at the camp, but high up in the sky above the islands Radcliff, Knorr, and Star were masses of little auks flying inland. In the hut we found mail from England, left for us by the Governor of Thule who had visited the camp just after we had left. Our journey was over.

Summer in Greenland

On the return of the Grant Land party on May 26 our chief work was over. Haig-Thomas had gone to Kanaq with some of the Eskimo returning to

their village. He was going to devote his time to ornithological work and we intended to fetch him later on so that he could do similar work in the neighbourhood of Etah. The other Eskimo went off on May 29. We had plenty to do: the marine motors had to be got in order, and equipment and stores which had been left behind had to be fetched by boat. The outboard motor was buried in the snow and for a time could not be found. The whaleboat with inboard motor was completely buried by sea-ice so that not a sign of it could be seen. Most of the work in this connection was done by Bentham, our geologist and marine engineer. The first slush was seen on May 25, the first running water on May 31. We had given away to the Eskimo all the surviving dogs except ten which, as long as the ice held, would be useful for fetching ice for drinking water from the glacier. On one of the trips, on June 3, when sledging to the glacier across Alida Lake, the ice gave way and the writer with the dogs and sledge went through. Summer had come. From now onwards the ice began to break up. The warm water melted the ice at the cracks, formed leads which later formed separate ice-pans. The first flower had been seen on June 9 but the vegetation was not fully in flower until July. By August the flowering season was on the wane. During the short season a complete collection was made of all the flowers which could be found on excursions from Etah. Insects were also collected, the first fly being seen on July 11. Collections of marine fauna were made from holes in the ice as long as the season permitted. Little auks were nesting by July 11 and some of these were taken for human and dog food, as after the ice went out seals could no longer be hunted successfully. Eider duck were now nesting on the islands which could not be reached by foxes. The last day on which it was allowed to collect eider eggs was July 17. The reason for this law is to allow clutches to be hatched early enough for the young birds to be sufficiently mature to fly south before the winter. By June 15 Bentham had got the outboard motor going and he, Moore, and Stallworthy drove the dory, engine, and sleeping-bags, food and tentage for five people across the ice to the ice-foot near Sunrise Point and thence along the ice-foot to an island just south of that known to us as Walrus Island. Here Bentham and Stallworthy camped, and Moore drove the dogs back to Etah. Next morning he returned on foot, arranging with Shackleton and me to meet them on the coast opposite Littleton Island at 2 p.m. that day. We then walked overland and waited until 5.30 when, our kit being on the dory, we returned. Meanwhile the boat had been delayed by bad weather and did not reach the meeting place until midnight. Not seeing us they went on to Mount Gary Island. Before going to sleep they collected about two thousand eggs. Half of these were packed in boxes and the rest cached. It was now that they discovered that the outboard motor had been knocked off the boat and had fallen into the sea, luckily where it could be recovered at low tide. They now went to sleep, one of them remaining on guard as the dory could not be beached and was liable to be smashed against the ice-foot. During Bentham's watch he roused the others. The dory had slipped its mooring and was drifting out to sea. This was a serious matter as the whaleboat was still imbedded in the ice at Etah and there were at this time no Eskimo who might have searched the coast in kayaks, while Shackleton and the writer imagined that the

others were going to Littleton Island, which island obscured a view of Mount Cary Island from the mainland. It might be long before the egg-collecting party was rescued. The dory was seen to be drifting across a small bay to a headland. Rushing to the ice-foot at this point they were just in time to throw an ice axe attached to a line and hook the boat. This was then pulled to below the overhanging ice-foot and Moore was let down into it. He then made the line fast and the dory was towed back to its original mooring place. It was now June 18 and they rowed back with the boxes of eggs to near Etah and beached the boat. On June 27 there arrived by ice-cap Nukapinguaq with his relations, seven in all. They had decided to settle at Etah. Eskimo men now went with Moore and Bentham to fetch the eggs cached on Mount Gary Island and also food left at Lifeboat Cove, returning the same day. Nukapinguaq now helped Bentham with the inboard motor which, after spending the winter under the ice, functioned once more on July 8. On the 11th the ice-pans floated out to sea, leaving the fjord clear. The next day, after a bathing parade which henceforth became a regular institution, Bentham got off with both boats and the Eskimo man in order to bring back more of the contents of the caches and to enable the natives to hunt walrus. On their return we celebrated Shackleton's birthday and at the same time the anniversary of the start of the expedition. On July 20 Bentham and I and several Eskimo made the final trip for bringing back the contents of the caches, and also to collect plants and rocks, and to enable the natives to hunt walrus. We returned on July 22.

On the coast of a small bay on the mainland just south of Radcliff Island is the grave of Sonntag, who had been a member of the Hayes 1860–61 Expedition and had perished. Eskimo told MacMillan that Sonntag's native companions had contrived his death, but our Eskimo told us that his drowning was accidental. Moore and I rowed out one day with a spade, a sack of earth, and a box of plants, and planted the grave with poppies, purple saxifrage and a small willow. We were now ready to fetch Haig-Thomas, but the day after our visit to Sonntag's grave we nearly lost the whaleboat. A sudden storm caused her to drag her anchor and she was driven on to the shore where the coast was steep, and she was in danger of being smashed to bits. However all hands turned to and by plunging into the water and fixing a line and then a pulley on shore, we were able to pull the whaleboat up the steep bank. The next day, July 29, a two-masted ship was seen. This we believed to be Captain Bartlett's *Morrissy*, which we had heard of by wireless a few days before as being at Thule. Sakeus, Nukapinguaq's son, went out with a telescope in his kayak to Thermometer Hill, which he climbed. On returning he reported that he had seen the ship launch a boat and he thought they had been hunting walrus. He also thought that he had heard dogs on board. When last seen the ship appeared to be making for Fram Haven. Thinking that the *Morrissy* was making a summer trip we still hoped she would look in at Etah, but not seeing her again by the first of August, Bentham, Shackleton, and I started that evening to fetch Haig-Thomas. Nukapinguaq and his wife Enilungwa wanted to go to Robertson Bay, so we took them with us. It was already colder and off the Crystal Palace Glacier there was fresh ice on the sea. Here we had an accident. Nukapinguaq's sleeve caught in the engine and his wrist was badly injured. Wishing to make a proper examination, if necessary

under a general anaesthetic, we returned to Etah. We left Etah again on August 5, with Sakeus in the place of Nukapinguaq, and reached Siorapaluk that day. Haig-Thomas came out to meet us in a kayak and we heard his news since he had left us two and a half months ago.

Our plan now was to return to Etah, landing at intervals along the coast for geological and botanical work. On the way back however landing in a heavy sea, the boat was swamped and grounded, and before we could float her again she had sprung a leak. This was repaired temporarily and we put to sea again, but in view of threatened bad weather and the damage to the boat we returned to Siorapaluk. Here we had the boat repaired, but were again delayed by engine trouble and strong winds until it was so near the middle of August that we were afraid of missing the relief ship which, if we started back, might arrive while we were held up on the coast between Robertson Bay and Etah. We were able to do geological and botanical work in the neighbourhood and were also able to get some kayaking. Especially interesting to us was learning to roll a kayak. None of the natives here had this art, but from an article in the *Polar Record* we were able to get the knack and once acquired the performance was extremely easy. While at Etah we had heard by wireless on July 17 that the *Dannebrog*, which was to relieve us, had passed Cape Farewell, and from this we were expecting to be relieved by the 14th. A week later, with no news coming through to us and no sign of the ship, we began to consider the possibility of having to spend another winter in the Arctic. Suddenly, at 1.30 a.m. on August 22, the anniversary of the *Signalhorn's* departure from Etah, Enilungwa burst into our iglu to say that the ship was in sight. Rifle shots could now be heard, fired by the natives in the village to signalize the great event. The ship was but a blur on the misty horizon, and it was a long time before we could go aboard, but when the time came we were received by Captain Petersen and shown into his cabin where we found smokes, drinks, food, and, most important to us, our English mail, which he left us to read.

When we reached Etah we had to pack as quickly as possible. During our absence Moore and Stallworthy were without knowledge of our whereabouts, but while planning for another winter had got ahead as far as possible with the packing. During our final arrangements the *Dannebrog* went out to hunt walrus as there was a shortage of meat both at Siorapaluk and Thule. At the last moment at Etah we gave a farewell party to the natives and said good-bye to them and to Etah at 3.15 a.m. on August 25. Owing to a storm which blew us out of our course, we took more than three days to get to Thule, where we were told that the storm had been the worst known there for fifteen years. We were shown windows with small holes in them as though bullets had been fired through. These holes had been made by wind-driven gravel. After again experiencing the unbounded hospitality of Thule we left for Umanak, Godhavn, and Ivigtut. At this last place we were shown the cryolite mine and entertained with a wholeheartedness which will long stay in our memory. And so we said good-bye to Greenland. Owing to being forced to winter at Etah and because of the abnormal weather conditions which prevented us from sledging north during the winter we had not been able to accomplish as much in Grant Land as we had hoped. We had however penetrated into

unexplored Ellesmere Island at five points, we had been able to make valuable collections and we had gained an enormous amount of experience which some of us hope to be able to use on future expeditions.

II. THE SCORESBY BAY JOURNEY

EDWARD SHACKLETON

ON April 4 Bentham and I left Etah *en route* for the main pemmican cache, a few miles north of Cairn Point. This meant a journey of about 20 miles, the first part of which was across rocky country. The first two parties, with whom we hoped to meet, had "packed" their loads up the hill behind the house, but our Eskimo chose a different route in order to avoid this laborious process, and so on a windy but sunny afternoon five sledges headed seaward. Four of these were driven by Eskimo, and the fifth by Bentham and myself, with sixteen dogs in our team. The two older and more experienced natives, Porsman and Ahnowka, were to accompany us on the whole trip, and the two younger men were to act as a support party, travelling with us until their pemmican loads should be used up. Porsman was a famous traveller among the Smith Sound Eskimo, for he had been one of the picked men who had travelled with the late Dr. Knud Rasmussen on his sledge journey round North Greenland, a starvation trip of which he had vivid memories. With comparatively light loads and a strong following wind we headed for Sunrise Point, but after 2 or 3 miles we met our first check, open water which compelled us to take to the ice-foot. It took us the best part of an hour to chop a way through the hummocks, but after this our progress was rapid until we reached a bay from which a long snow slope stretched steeply up into the hills of the interior. A tearing wind with high drift was sweeping downhill, and our dogs were even more reluctant than we to face the stinging clouds of snow. In patches too the ground was bare, and the sledges frequently stuck. Finally, by dint of much shouting and the use of the long whips, we topped the slope and drove along the comparatively level uplands. The wind soon abated, and we made fairly good progress over the divide and down to the sea ice on the other side, where we made camp. From this point we had a good trail, and although in places we had to take to the ice-foot owing to open water, we made steady progress towards the main pack lying north of Cairn Point. The nearer we approached it the colder it became, and as we crossed Refuge Harbour, MacMillan's old winter quarters, an icy wind met us. At this point the sledge trails led to open water, where some ice had apparently gone out after the other parties had passed, and with a certain amount of difficulty, owing to the very low tide, we dragged the sledges up on to the ice-foot, 20 feet above the level of the sea. We finally drove into camp with our faces frost-bitten, only to find the others had already left that day. The following day was taken up with polishing the steel sledge runners, which were badly scored from the land crossing, collecting the cases of Bovril dog-pemmican, and finally distributing the loads, and lashing up. This took a good deal of time, and it was after sunset that we headed out to sea, north-west along the trail made by Humphreys and

his party the previous day. Our previous two days' travel had brought us into a different climate. When we set out from Etah the temperatures were a good deal higher than during the previous months of February and March, but after we had left the open water and taken our course over the sea-ice, we seemed to drive back into the coldest part of the year. It was by now light enough to travel through the night, but the sun was not permanently above the horizon yet, and during our first night's journey we encountered between 60 and 70 degrees of frost. However occasional patches of rough ice, which entailed a certain amount of work, kept us warm and as the ice conditions improved we kept up a rate of travel which enabled us to run behind the sledges whenever we felt cold. We stopped to boil some tea at Humphreys' first camp on the floe, but as we were very anxious to catch him up, we pushed on another two or three hours' distance, camping in the light of the rising sun.

We continued after an early start, and another twelve hours brought us to the police depôt at Fram Haven. To reach this we had to travel through some very rough ice, with deep snow between the piled-up floes, but we were fortunate in having a trail ready made for us. Indeed it was largely due to the fact that the first party had pioneered a way for us that we were able to make such good time across Smith Sound. The value of this was all the more apparent when the following morning Sakeus, our youngest Eskimo, complained of a sharp pain in one of his eyes, as if it were full of iron filings. This description so exactly fitted the symptoms of snow-blindness that we immediately concluded that it was from this that he was suffering. An examination however soon showed that it was indeed an iron filing that was causing the trouble, a result no doubt of his work polishing the steel runners of his sledge the day we set out from Greenland. There was no choice but to push on as quickly as possible in the hopes of catching Humphreys, and to this end we decided to make a forced march right through to the old police detachment at the entrance of Flagler Fjord. With good ice conditions this would mean a journey of 35 miles, but under present circumstances we should have to make a wide detour of over 50 miles, much of it through heavy ice. We collected from the depôt various articles of food and equipment that would be of use to us and set out about ten in the evening. We reached Cape Albert about six the following morning, and cached our reserves of dog-feed and provisions. A little farther on Sakeus was in such pain that it was clearly impossible for him to continue to drive his sledge across the glaring snow and ice. His eyes were bandaged and Porsman took him on his sledge, with orders to push on as quickly as possible, while Bentham drove our sledge and I managed one of the Eskimo dog teams. I think that was one of the longest days of the whole trip. Later on we became accustomed to sleeping at twenty-four hour intervals, but there was not one of us on this occasion who did not, as the trail improved, fall asleep on his sledge. We finally drove into the former police outpost about three in the afternoon, and there we were relieved to find Dr. Humphreys, who immediately performed a successful minor operation, after anaesthetising the injured eye.

Humphreys and Haig-Thomas left for the north on April 11 and on the following day Bentham started on a collecting trip to the seaward end of the peninsula. On the 13th, accompanied by Porsman and Sakeus with two

sledges, I drove up Flagler Fjord to reconnoitre a way across the peninsula with a view to examining the glaciers that discharge into Princess Marie Bay. We had excellent going up the fjord, and thanks to Sakeus who knew the surrounding country very well we had no difficulty in picking a very easy route for our lightly loaded sledges. The peninsula at this point narrowed to a neck not more than a mile and a half wide, though the existing maps gave it a greater width than this. After stopping to make tea we were soon across, and the sun had set and risen again by the time we had topped the height of the pass, only 700 feet above the level of the sea ice. A steep descent over rocks meant some care to prevent the sledge getting out of control and overrunning the dogs. Sakeus acting as a brake to the sledge, with myself in front whipping the dogs back, managed all right, but Porsman who followed, shot past at about 30 miles an hour, shouting at the top of his voice, finally ending up in a hopeless tangle, with the dogs underneath the sledge. The next day we set out to examine the Sven Hedin Glacier, which discharged into Woodward Bay. We were soon climbing the terminal moraine across which ran several crevasses, but at a height of 40 feet we found that we were only about half-way up the face of the glacier. So much for our hopes of an easy ascent. For the most part it was at least 60 feet high and scored by huge crevasses and fissures visible along the topmost edge, except in places where snow softened the outline. The talus in front of the glacier, the badly crevassed condition of the terminal moraine up which we had climbed, and the convexity and sometimes vertical angle of the glacier snout, all indicated that the glacier was advancing. It was necessary to return at once, so that Bentham could benefit by the information we had gleaned in carrying out his all-important geological work. The long hours of the return journey were more of a test of the dogs than their drivers, but we were so lightly loaded that when we again descended to the smooth ice of Flagler Fjord they could gallop along at a good pace. We eventually arrived back on the afternoon of the 15th, after a twenty-four hour day, during which we had covered about 70 miles. Bentham had already returned from his geological trip, and had found a number of very valuable Cambrian fossils. We spent the next few days hunting seal, but for some reason they had disappeared, and after I had taken a series of observations for latitude and longitude, we realized we should have to leave for our pemmican cache in order to feed our hungry dogs. Thence we intended to push northward to Scoresby Bay. On April 25 therefore we set out for Cape Albert, at the eastern end of Bache Peninsula, and having emptied our depot of provisions we headed out into Kane Basin. For the first two days our progress over the sea-ice was slow, since our dogs were in very bad shape and ice conditions were unfavourable. However by climbing the bigger pressure ridges, some of which had been piled as high as 25 feet, the Eskimo had been able to pick out the best route, and so we managed to steer clear of any really rough ice. After three days on the trail we had covered 80 miles, but our fourth day was destined to give us a harder task. After a couple of hours' travel we found the Eskimo had halted at the foot of some huge pressure ridges, and they greeted us with the information that there was bad ice ahead. It certainly was bad. The next hour we scarcely made a mile's progress; although the temperature was below zero we threw off all our extra clothing, and laboured to find a way

through the chaotic floes. Axes were in continuous use, for the sledges and dog-traces were continually catching up on the ice pinnacles, and whenever a sledge topped a particularly high ridge of ice it would race down the other side and bury the runners in ice and snow, which we then had to chop free. But the deep snow that lay in the hollows was the worst feature. Quite suddenly the sledge runners would sink out of sight and then the dogs had to struggle along on their bellies, and we never knew whether the next step would be on a sharp piece of ice, or whether we should find ourselves up to our thighs in the snow. After a time however conditions improved, and we crossed a huge palaeocrystic floe, tremendously thick and worn and weathered during countless years, into an undulating country of miniature hills and valleys. On this the snow was packed much harder, and for several hours we made good progress, driving up and down hill until we were nearly half-way across Dobbin Bay. Then a few more patches of rough ice and we swung due west on to a wonderful smooth stretch of ice. Here under the shelter of a huge pressure ridge, which marked the limit of the rough ice, we made our camp, after being on the trail for eleven hours.

The following day we set out over excellent smooth ice, and made fast time in the direction of Cape Louis Napoleon. After a couple of hours' travel two of the Eskimo stopped by some seal holes in the hopes of a shot, but they were out of luck. Towards evening, as we neared Hayes Point, patches of rough ice began to occur and we were finally stopped by a barrier even more impenetrable than the previous day's ice. We had no choice but to force our way through to the mainland, about 3 miles distant, in the hopes of finding a good ice-foot. This possibility the natives regarded rather dubiously. For the next hour and a half there was such a pounding and jarring of the sledges that it seemed an absolute miracle that they were not smashed beyond repair. Although the temperature was below zero, for it was about midnight, we were all drenched with sweat, and by the time we reached land our beards, eyebrows, eye-lashes, and hair were white with frost. The dogs were completely worn out, but we had now reached a broad highway of smooth ice and we pushed on for a couple of hours, finally camping just south of Hayes Point. By chance we had struck a fossiliferous area, and Bentham was able to make a good collection of Silurian trilobites, gastropods, and brachiopods. The ice-foot was wonderfully smooth by Hayes Point, where we had halted, but already there were warnings of trouble ahead, if we had been able to read the signs, for some huge boulder-shaped pieces of ice had been piled up here and there on the seaward edge of the ice-foot, an indication of tremendous pressure the previous open season. The following day we pushed on as rapidly as we could, hoping that the excellent ice-foot would continue far to the north, since the sea-ice was impracticable; for with our big dog-teams, so essential for the conditions of travel amid the gigantic floes of the Polar pack, we could not hope for anything like the range of travel that belongs to a party sledging over the smooth surface of the ice-cap. So far we had seen no seal, and our stock of pemmican was diminishing rapidly. As we made our way along the shore of the Darling Peninsula, we reached a bay of curious formation. A 10-foot bank of gravel marked the limit of a remarkable stretch of smooth shingly ground, with occasional shallow patches of soft snow. Inland a glacier

was visible and on either side the hills sloped gently down to the plain, a striking contrast to the usual steep 1000-foot cliffs which marked the coast-line elsewhere. Accidentally we had hit on an ideal landing ground for aeroplanes, which might perhaps in the not so far distant future be used at all seasons of the year. The condition of the snow showed too that the locality was free from winds. Temporarily therefore we decided to christen it Aerodrome Bay. From this point on the ice-foot deteriorated. In places we had to take to the hummocks, and when later we were able to regain it, it was covered with dirt and stones from the hillside, which was very hard on our steel-shod runners. The sea-ice too was covered in rock detritus, and a huge wall of floes bordered the ice-foot. So we continued until just south of Cape Fraser we found our way was barred by an indescribable chaos of piled-up floes. The ice-foot completely disappeared beneath the huge blocks which reached 30 to 40 feet from the sea up the hillside. I had never imagined anything so devastating as the power which could produce such an effect. Millions of tons of ice had been forced out of the sea by pressure so enormous that nothing could have withstood it; and yet this was the sea through which Peary and others forced their ships on their way to northern latitudes. After reconnoitring along the hillside we soon saw that there was nothing for it but to take to the sea-ice again, rough though it might be. We had to chop a way over the rampart of jumbled floes that had lined the ice-foot for the last few miles, and it took us over half an hour to lower the sledges to the level of the sea-ice. We finally made camp about 3 miles south of Scoresby Bay, close to an outcrop of rock which had attracted Bentham's interest as a geologist. This locality exceeded all his expectations, being highly fossiliferous, and since Scoresby Bay was unexplored territory and immensely interesting from a geological standpoint, we decided to devote some days to a thorough investigation of the neighbourhood. Our most immediate need was to rest the dogs, and so we turned in for the night with the feeling that we should be able to sleep our fill. We were to have a most rude awakening. During the night a blizzard rose, and we heard the howl of the wind and the snow rattling like small shot against the walls of the tent, but we were too comfortable to be disturbed by this. Suddenly however we were all wide awake. The blizzard had stopped, but a heavy roar filled the air. We could feel the floe on which we were camped, about 50 yards from the ice-foot, vibrating and cracking. The tent shook as if in a gale, and above all we could hear the tremendous crash of rending ice. We were out of our sleeping-bags in a second and undoing the tent-flap. We all had vivid ideas of some catastrophe. Bentham and I imagined the ice breaking loose as a result of the night's blizzard, and being smashed to pieces between heavy floes and the shore ice. The Eskimo were nearer the mark, for they visualized the whole ice-foot, with its vast load of pressure-ice, crashing down on us. Fortunately it was not quite as bad as this for, as we soon saw, the main ice-foot was intact. Nevertheless a huge section of ice, weighing thousands of tons at least, had crashed on to the floe, shivering it in all directions. Several large cracks ran from the shattered area, and some of the dogs had broken loose in the terror of the moment. We were soon back in our sleeping-bags.

On April 29 Bentham began a detailed examination of the rocks in the neighbourhood, as far as Cape Norton Shaw, the southern cape of Scoresby

Bay, while I set out with one of the Eskimo to reconnoitre Scoresby Bay. (This had previously been passed by other explorers bound for higher latitudes, and Humphreys had thought that there was a good chance of making some interesting discoveries. Bentham's chief interest was to find the junction between the Silurian and the Cape Ransom beds, which according to Fielden extend north from Scoresby Bay.) Travelling with a light sledge and a big dog-team, we had soon rounded Cape Norton Shaw and were heading up the bay along the ice-foot. After travelling about 8 or 9 miles we noticed the bay was tending to bear more and more in a southerly direction. We soon realized that it had a very different shape and extent from that shown on the map, being more in the nature of an inlet than a bay; and as we swung farther and farther south, we lost sight of the seaward end of the bay, and high mountains came into view on its western side. Just as we swung round the last bend on the ice-foot, into sight of the end of the bay, the whole dazzling range of the Victoria and Albert Mountains sprang into view. Their foothills rose straight from the sea-ice and the highest peaks were not more than 7 or 8 miles inland, although shown on the map as at least 20 miles into the interior. This was because the only view of them seen by Nares, who had placed them on the map, was from the deck of his ship some distance out to sea. One mountain was particularly magnificent, rising steeply to a height of over 5000 feet, as near as we could judge, and entirely encircled by ice at a height of about 2000 feet, flowing from the ice-cap. Some small glaciers too could be observed, and at the southern end of the inlet was a low, gently rising plain, leading up to a divide which presumably separated Scoresby Bay from Dobbin Bay. A solitary mountain guarded the divide. We drove on up the inlet and about 5 miles from its head were able to take to the sea-ice, which was by now free from the old floes which were jammed in the mouth. We were finally able to distinguish the low-lying southern shore-line from the sea-ice, and at this point we stopped, as I intended to return to camp the same day. I took a few photographs and some compass-bearings, but it was too cold to spend long at it. A little wind was whipping the snow off the ground, and so we decided to return to a warmer neighbourhood than this sunless valley. In the meanwhile Bentham had spent a profitable day collecting, although somewhat hindered by the previous night's storm, which had covered the rocks with a thin layer of snow. We were both rather excited by the discoveries in Scoresby Bay, particularly the mountain range which, according to the map, should have been many miles inland. There was no doubt that this must have been the range seen by the Nares Expedition, and subsequent investigation supported this conclusion. If there is a chain of mountains in the interior of Grinnell Land, it must have been far beyond the range of vision of any of our predecessors. So we made detailed plans for completing our work at Scoresby Inlet, and it was arranged that Bentham should move camp to the head of the inlet, while I was to spend one night at Cape Norton Shaw, set up the wireless so as to get time-signals, and then take some observations for latitude and longitude. As soon as this was finished I was to join Bentham, and we then hoped to make an attempt on the highest mountain in the Victoria and Albert Range, in order to get a good view into the unknown interior of Grinnell Land.

In the early hours of May 1 we drove to Cape Norton Shaw and there,

after building a snow iglu, Bentham took two Eskimo and continued on his way. The Stratton S.W. Receiver was soon set up, and I was able to get some good time-signals for correcting times of observations on the sun. Even more interesting was the fact that though I had only a two-valve set, I easily heard news bulletins from the Empire Short-Wave Station at Daventry, and later from American Stations, notably Pittsburgh, Philadelphia, Schenectady, and Cincinnati. Unfortunately the following day was too cold to hope for anything but an extremely hurried series of observations, which would be no improvement on existing data, and so I had to abandon the attempt for this day at any rate, and as I was not feeling at all well, I at once drove to Bentham's camp.

In the meanwhile Bentham had set off to climb one of the foothills below the high mountain which I had particularly noted on my first trip up Scoresby Inlet. He started off up a valley, but found the going very difficult. There was over 2 feet of soft snow into which he sank at every step, and the hillside was even worse. However he plodded on for four hours, by which time he realized he would never reach the summit without a sleep. He then turned to retrace his steps, but found the descent even more exhausting. Unfortunately he had not anticipated these conditions and so was not wearing snow-shoes. The conditions were particularly trying since there was a thin wind crust on the snow, and it was of such a nature that it would bear the weight of the foot at first, but as soon as the other foot was lifted down went the first into 2 feet of snow. To add to his troubles he felt an attack of snow-blindness coming on, and it was imperative he should get back quickly, in case it developed and it became impossible to travel. However by keeping his eyes half closed and resting at short intervals, he managed to struggle safely back into camp. This preliminary excursion showed that in the circumstances the attempt to climb the main peak would take a considerable time, and could only be accomplished if the weather held out for at least thirty-six hours. There was likely to be deep snow right up to the summit and in addition it would be necessary to cross a tongue of the ice-cap, which was almost certain to be riddled with concealed crevasses. The following day there was dense cloud and any attempt on the mountain was impossible. In addition I was unfortunately too ill to get up, the trouble evidently being some kind of poisoning. Bentham spent the day travelling along the north-west side of the Inlet, collecting fossils and looking for the junction between the Silurian and the Cape Ransom beds, but his discoveries were of a negative nature, for the whole of Scoresby Bay was Silurian as far north as Cape McLintock.

Our Eskimo had been completely unsuccessful in their hunt for bear and seal, and our total bag up to date consisted of one Arctic hare. There was only pemmican enough for three dog-feeds left out at the point, and the dogs had not been fed for two days. The wonderfully fine weather of April, clear and cold, had broken: most days the sky was overcast and a south wind threatened more blizzards. We had in front of us a journey which on the outward march had taken us seven days. It was impossible to delay any longer our return to Bache, where we might hope to obtain seal, and so save our dogs from starvation. Our sledges were now much lighter, and thanks to our experience on the outward march we were able to avoid the worst of the bad ice. By the time

were found

Pressure ridge on ice-foot, N.W. Greenland

Gulley behind Bache Peninsula, where Cambrian fossils were found

N.W. side of Scoresby Bay: Peak 1 approximately 6000 feet

N.W. side of Scoresby Bay

we reached Cape Hawks, south of Dobbin Bay, we had finished all our dog-feed, but on May 7 and 8 we made a forced march to Cape Albert, covering 50 miles without a sleep, and so finished the last part of our journey, driving up to the hut at Bache Peninsula in glorious weather on May 9. The Eskimo immediately went out hunting and brought in four seal for the dogs, which were by now ravenous.

We now decided to spend some days completing work which we had been

unable to do during our previous visit to Bache Peninsula. Bentham crossed over into Princess Marie Bay and spent five days collecting in that neighbourhood, while I travelled with a native to Alexandras Fjord to search for ancient Eskimo remains. This however turned out to be very difficult owing to the deep snow; but Bentham had a successful trip and we finally set out for Etah on May 18. We had to abandon one of the sledges which had been smashed beyond repair, and so it was with only three sledges and with a diminished number of dogs that we finally set out for Etah. There were already signs of a thaw. The ice which Bentham had had to cross at the mouth of Flagler Fjord, on his way back from Princess Marie Bay, had been very rotten. In fact there was a certain amount of lead-jumping to be done before his party

could get through, and the Eskimo were now eager to return home because they feared the ice in Smith Sound might break up at any moment; this would necessitate a long detour to the north round the edge of the open water. During our first day's march we covered at least 40 miles and were over fifteen hours on the trail. This took us far out into the Sound, and when we broke camp in the early morning of the 20th the weather was very threatening, especially towards the south, the quarter from which we could expect a blizzard. However we could see the Greenland coast and we pushed on as rapidly as possible, as we had no wish to be caught in a blizzard in the middle of Smith Sound at this time of the year. The next time we might see the coast would perhaps be from a drifting floe! After a short distance one of the Eskimo shot a seal, and the dogs being very hungry we stopped to feed. Meanwhile it came on to snow fairly hard and we had no choice but to wait for the weather to clear, since although we could have steered a compass course, it might have landed us in open water, if the ice had gone out close to the Greenland side. However after about an hour the snow ceased and a wind cleared the air enough for us to distinguish land. But this was only a short respite. About 2.30 p.m. a strong wind got up, whirling the newly fallen snow into clouds. A little later the land was hidden from sight and in a flash the sledges disappeared. The wind was now blowing half a gale and rising every moment. Immediately the sledges disappeared from sight Ahnowka and Bentham who were leading, stopped and we were soon together again. There was no choice but to make camp at once, before the full force of the rising blizzard struck us. This was no easy matter, for the tent behaved like a wild thing and it took five of us all our time to get it up. Indeed it is doubtful if a quarter of an hour later we could have accomplished it. Already visibility was reduced to a few yards by swirling clouds of snow, and the dogs lay covered in drifts which had formed almost instantly. We were soon safe in the tent and there we were able to appreciate the full force of the blizzard almost better than outside, for the canvas was cracking and banging as if a bombardment was going on. Every now and then a more violent explosion startled us into the belief that the tent would be ripped to shreds, and once we thought we might have to take the poles out and let the tent down so that the snow could drift over it. At the leeward end there accumulated a drift of snow half the height of the tent, and this pressed heavily inward; but the tent, a standard model made by Messrs. Black & Co., of Greenock, stood every strain. So we spent the next thirty-six hours, and it was not until the evening of the next day that we were able to set out. We then discovered that we were encamped within half a mile of open water! However it was just as well for our peace of mind that we had not known this before. Whatever happened we felt we were safe with a south wind, which would only tend to pack the ice more closely.

Although our sledges were buried deep in drifts and had to be dug out, the ice itself was in perfect condition, for the wind had swept all the loose snow off the surface and what remained was packed hard. So we made excellent time and soon reached land close to Cairn Point. Near the shore the ice was very thin and rotten, and we had to take to the ice-foot. In one place we had to lower the sledges on to floating ice-pans and ferry them round a point where the ice-foot had collapsed, as we discovered afterwards, beneath one of the

sledges of Humphreys' party, crushing six of their dogs to death. After this we followed practically the same trail as on the outward journey and camped in Hatherton Bay on the afternoon of May 22, after about sixteen hours on the trail. We were now only a short distance from Etah and the land-crossing was our sole remaining obstacle. Although this had proved one of the most difficult parts of the whole journey on the outward march it turned out to be much easier now with our lighter sledges. In addition a good deal more snow had fallen, and many of the rocks which had caused us trouble before had disappeared.

So we arrived back at Etah in the early hours of the 24th, after a journey of 800 miles. Our Eskimo were so keen to reach their sealing grounds in the south that they decided to leave that same day with Humphreys' natives who had arrived back the day before us. So after paying them off and giving them all the tea, coffee, flour, and other food they could carry, we finally bid them a sad goodbye. Porsman in particular we were sorry to part with, for although they had all served us faithfully we had an especial affection for him as for an old friend. It was his energy, endurance, and cheerfulness, and that of his companions, that brought us such small success as we attained.

III. THE SLEDGE JOURNEY TO GRANT LAND

A. W. MOORE

AT noon on 3 April 1935 the Grant Land party drove northwards from Etah in a gale. The party consisted of Sergt. H. W. Stallworthy, R.C.M.P., two Eskimo (Nukapinguaq and Inuatuk), and myself. There were also two Eskimo sledges in support carrying dog food; these would travel with us as far as Cape Calhoun, which lies north of the Humboldt glacier at the entrance to Kennedy Channel. Our point of departure was the summit of the steep ravine behind Etah, where on the previous day all the stores and equipment had been "packed" by us, thus saving much time.

After travelling for twelve hours we drove up to the large pemmican depôt established during the previous autumn. It was very cold with a biting north wind blowing and the thermometer registered −32° F. As anticipated, we found Dr. Humphreys' party encamped here. They had started a day earlier than us, and we had followed their route, thus being spared hours of hard work consisting of chopping ways for the sledges through huge hummocks of pressure ice which had piled up on the shore. On our arrival the camp was in deep sleep, and after pitching our tent on the sea-ice we too were soon in our sleeping-bags enjoying biscuits and steaming hot coffee. The next day we spent in allocating the loads for our sledges, and in filing down the steel runners which had suffered badly on the rocks during the overland crossing from Etah to the sea-ice. Humphreys' party was the first to leave the depôt, setting out the next morning across Smith Sound for Ellesmere Land. We watched the sledges until they disappeared like tiny black specks over the white horizon. That evening we drove northwards. Our sledges were heavily

laden, the top of the loads being very little below the top of the sledge handles, and the average load being about 700 lb.

For the first few days we travelled mainly along the shore-ice; the going was fast and during these days the dogs pulled well and were lively. Little did they guess however what the future held for them, and those which overworked now were the first to collapse when times were hard. Our first long trek over the sea-ice was across Peabody Bay. Here lies the huge Humboldt glacier, the largest in the Arctic, at the north end of which we would strike land again at Cape Calhoun. Immediately before setting out across the bay, we met two Eskimo returning from a hunting expedition. It was no great surprise to meet them, since we had been following sledge tracks for several days. These hunters were out of luck and in a bad condition. Their dogs were starving and they were almost without human food. They were killing dogs to feed the others, and it was lucky that we were able to help them a little. One of them had got his cheeks badly frostbitten while on the ice-cap, showing large raw patches where the skin had stripped off; and the other was permanently lame, and without his dog team would have been in a serious position. Their misfortune was due to there being no open water at Cape Calhoun, upon which the Eskimo rely year after year for hunting seal. This year however the water was absent and the hunting a failure, since it was too early to find seal upon the ice. Neither had they seen any polar bears, although they had followed up recent bear tracks. Before leaving them we gave these men some provisions to get them back to Robertson Bay, and if they called in at Etah they could replenish there. And so we struck out on to the sea-ice where the going was more difficult, but we knew where the best route lay since the Eskimo hunters were able to give us good information on that point.

The snow was harder well out from the shore, but even so what a difference a little of the Etah wind would have made: a horror during the winter, it would have been welcome here to harden up the surface of the snow. The expert knowledge of polar travel possessed by our Eskimo now came into evidence, and if there was a stretch of good ice anywhere around they would find it. Often we pursued a winding course through rough ice when it scarcely seemed necessary, but before long we were to find out that for the hour or so of difficult going we would be rewarded with good travelling for the best part of the day. This was entirely due to the amazingly quick eye and unerring instinct of our Eskimo, and it persisted throughout the whole journey. Often Nukapinguaq would suddenly whip up his dogs and gallop ahead to some distant iceberg; there he would sit motionless on top with the glasses glued to his eyes for what seemed to us ages. As we drove up he would descend and once more gallop into the lead, the route for the next few hours carefully locked up in his brain.

Our first day in Peabody Bay was a lucky one, for we got four seals at their breathing holes along a crack in the ice. The Eskimo stood over the holes, rifle in hand, and when the seals came up to breathe discharged a soft-nosed ·303 into their heads, following this up with the harpoon. For three days we travelled far out from the coast and met several recent bear tracks. Towards the end of the third day, when we were thinking of making camp, the dogs

all at once scented fresh bear tracks. They were only a few hours old, and we decided that three of the Eskimo should take up the hunt. Everything was hustle and bustle, loads were flung off the sledges in all directions, and within a minute or two the hunters galloped off in hot pursuit, carrying only rifle and harpoon. The dogs knew what was afoot, and as they drew away from camp we could see them straining at their traces, eager to come to grips with their quarry, and as they faded into the distance we still heard the incessant cracking of whips and the "bear talk" of their drivers. A good feed of bear meat would mean a great deal now to our dogs, as they were quickly losing their energy and the effect of the seal feed a few days before was wearing off. The heavy loads were beginning to tell and the pemmican did not satisfy our ravenous dogs. Hours later we saw the hunters returning far away on the horizon, and as they drew nearer we knew by the way they were talking to their dogs that they had got a bear. Later, when we were all enjoying a feed of polar bear steak, they told us how they had rounded it up at an iceberg, and after the kill had skinned and cut it up on the spot. One of them had gone in pursuit of a second bear, but his dogs were new to the game and after a chase of three hours the bear escaped. And so fifty-nine hungry dogs got their promised feed, and later they curled up in the snow and slept for a whole day.

After travelling for eleven hours the next day we reached Kennedy Channel, and here we got our first taste of warm spring weather, with the hot sun beating down upon us. The scenery here was very striking. Across the narrow channel the rugged mountainous coast of Ellesmere Land stood out in splendid contrast to the rather flat coastline of Greenland, and the glitter from the rough ice which filled the Channel lit up the scene vividly. At this stage of the journey we said goodbye to our support Eskimo. They left us to return south, after doing excellent work, and they had formed an important link in our organization. Progress up the channel was slow and the work was hard, but we had expected the worst here and so the endless chopping through rough ice, the heaving and tugging of our sledges over hummocks of pressure ice, did not dampen our ardour. Most of the strenuous chopping work fell to Inuatuk, who was excellent, and at the finish when the sweat was freezing on his body he would turn and give us a broad grin of satisfaction. Owing to bad ice conditions we were forced to travel farther north up the Greenland coast than we expected before crossing over to Ellesmere Land. Greenland bade us a very chilly farewell, which kept us inside our tent for two days. It blew hard, with drifting snow and extreme cold. Although the temperature was $+10^{\circ}$ F. we should have welcomed -20° with no wind, and should have been appreciably warmer. During these two days the lamps were given very little rest and we used up a lot of oil. It was a misfortune that there was not enough snow to build an iglu in which we should have been quite warm and comfortable without a lamp burning. During the whole journey we were only able to build one snow iglu, but our tent withstood the rigours remarkably well. Two days at this camp were enough for us, and we decided to start across Kennedy Channel, blizzard or no blizzard. Before leaving here we had to repair our sledges, since the trek up the channel had taken its toll by breaking handles, cross-slats, and splitting the runners.

The first few miles out from the coast were very trying: the dog-lines got

caught up continually in the rough rubble, and the dogs seemed to delight in pulling the sledge into blind alleys. Much to our surprise the rough ice suddenly ended, and soon we were making good progress over old smooth undulated ice, which continued almost to the coast of Ellesmere Land. Visibility was very poor, and later when a snowstorm blew up we could no longer see the sledges ahead of us. However we could follow their tracks, except when our dogs for no apparent reason decided to go off in another direction. Thanks to a splendid piece of pilotage by Nukapinguaq we crossed the channel within a few hours. During the whole way across he could see only a few yards ahead, but he never faltered in leading us straight across to Ellesmere Land. Once there the weather improved, but the ice got rough again and a nasty wind was blowing which forced us to camp just south of Lady Franklin Sound. At the end of the following day we drove, or rather crawled, into Fort Conger with exhausted dogs. We had made a long detour round a barrier of rough ice which blocked the entrance to the Sound; then we got into very deep snow. There was a thin crust on the top of the snow and it was granulated beneath; it was very hard on the dogs' feet, many of which were bleeding at the end of the day. Without a doubt the dogs were in extremely poor shape on arrival at Conger. We rested here for two days before proceeding to Lake Hazen, and had hoped to see a seal or two up on the ice in the harbour, but we were disappointed. During our stay we occupied Peary's old hut, over which we flew the Union Jack. We could find no record here of previous visits, but deposited our own record in a cairn on the summit of the hills behind Conger. A cache of supplies laid for Amundsen in 1917 was examined, but most of the contents were ruined; the pemmican however was in good condition, and became an important addition to our future food supply. An important saving in oil was made here, since we were able to use coal found *in situ* for cooking purposes. The deposit was discovered by the Nares Expedition in 1875.

It was necessary to get to Lake Hazen with all speed, because we badly required dog-feed and the prospect of large quantities of fish was a bright spot in the future. We were three days in getting there, and although apart from deep snow the going was not bad the dogs arrived there in a wretched condition. The first day out from Conger we saw a herd of musk oxen, some of which had calves. Nearer the lake we met another herd, which we tried to get near enough to photograph, but they made off into the hills. We had hoped to see them assume their defence formation, when they stand in a ring with heads facing outwards and their calves protected inside the ring. Our first camp out from Conger was the coldest during the whole journey. We were in the middle of a wind-swept valley, and the cold struck up fiercely from the ground through the deerskins beneath us. Being unable to follow our chosen route to the lake, owing to insufficiency of snow and the presence of rocks in the ravine, we struck out farther to the east, but after travelling for twelve hours saw no sign of Lake Hazen. We got our first glimpse however of the United States mountains, which form the barrier against approach into Grant Land. The next morning we arrived at the east end of Lake Hazen, and although there was a surface of deep crusted snow we found the ice only 4–5 feet thick. Within a few minutes of our arrival we had bored holes through

the ice and were pulling out char varying in size from 6 inches to 3 feet. The size and weight of the fish was disappointing, for the Eskimo expected to find them much larger, and so did we after reading Peary's records. Under the circumstances it was necessary to fish almost continually for the twenty-four hours of the day in order to procure a normal feed for the dogs. Stallworthy and the Eskimo displayed unbelievable patience at this fishing, and even slept on their sledges over the holes, occasionally waking up to "jiggle." The method of fishing adopted was simple and effective. A hole about 15 inches in diameter was bored through the ice, then the snow was cleared well away from around the hole so as to let in the light and attract the fish. A baited hook attached to a line was now lowered into the water, the bait being generally a piece of bacon or fish. The angler squatted over the hole, jigging the line up and down, and when he felt a tug at the end he jerked up the line smartly, generally hauling out a fish. A hook which attracted the fish most was an Allcock to which a small spinner was attached. Sometimes the fish escaped from the hook while being pulled up the hole, and when this occurred the angler put his arm into the hole, grabbed the fish, and brought it up again. Our eyes soon got very tired, due to the continual staring into the water, and the surface water froze over very rapidly unless skimmed at frequent intervals.

We had meant to fatten up the dogs at Lake Hazen before making the attempt on our final objective—the penetration of Grant Land and a crossing to the north coast at Cape Columbia. All did not go well however since the quantity of fish caught was quite insufficient and the fish were very thin. Instead of getting fat, the dogs were merely existing on very small feed, and it was quite clear after five days' fishing that some modification must be made in our plans and some sacrifices made. The new plan was as follows: Two members of the party with one sledge were to make the final dash across Grant Land. Nukapinguaq and myself were to make the attempt, taking with us a large team of the best dogs available and most of the dog pemmican. Stallworthy and Inuatuk would remain at the lake fishing, and would if possible lay in a cache of fish for our return. Stallworthy, who is a very experienced Arctic traveller and was the technical adviser to the expedition, generously waived his claim to be in the final effort. This was no mean sacrifice and meant days of monotonous fishing, but he turned to this task with his never-failing energy and enthusiasm.

On April 29 the Grant Land party left Lake Hazen, carrying on the sledge the minimum of equipment and enough pemmican to give the seventeen dogs eight feeds. After crossing to the north side of the lake the route lay through a winding valley behind the Garfield mountains, which lie adjacent to this side of the lake. We climbed steadily in deep snow through this valley, and it was very heavy going; often we sank to our thighs in the snow; then suddenly it would become very shallow, leaving boulders and rocks exposed and making it difficult to drive the sledge along. Generally one man was breaking trail ahead, while the other drove the dogs; this latter job was mostly done by the Eskimo, who gave a magnificent performance of dog-driving. Often the dogs were almost buried in the snow and had to be continually urged on with whips and tongue. The incessant cracking of the whip sounded like the firing of pistol shots to the man breaking trail ahead. Not only had the dogs to be

kept pulling, but the driver had to push, lift, and tug the sledge over the bare rocks on the valley bottom. We were forced to take frequent rests, and when the time for these arrived we both lay across the sledge exhausted, while the seventeen dogs lay as if lifeless. The sun was so hot and we sweated so profusely during the climb up this valley that we often stripped bare to the waist when on the move. Our first camp was in this valley and we slept on our deerskins covered by a tarpaulin, under the shelter of an overhanging cliff. Standing motionless on the edge of the cliffs we saw an aged musk ox, evidently an outcast from the herd, and climbing up within a few feet of it we took photographs and Nukapinguaq cracked his whip in front of its nose, whereupon it gave a loud snort of disapproval. The snow in this valley provided the worst going throughout the whole journey from Etah, and it was unsuitable for snowshoes, which we abandoned. A thin crust covered the coarse granulated snow beneath, but the crust would not bear our weight and so we sank at every step.

Our second day we arrived at the Gilman glacier, which looked a sheer wall from end to end, but after traversing the foot of it we saw a possible way of ascent at the extreme western edge. We unloaded most of the kit and packed it up the steep ice slope, cutting steps as we ascended; then we drove up the empty sledge. Once on the glacier the travelling improved greatly, and we found a fairly hard snow surface on the ice-cap. Ahead of us lay a long steady climb, but nothing mattered now, since we were penetrating the United States Range. That night we camped at 3000 feet, building a rough shelter of snow blocks on the windward side, and we slept soundly in our bags. In the morning on waking, Nukapinguaq anxiously told me that he had dreamt that Shackleton and Bentham had fallen through the sea-ice with their sledge and were drowned, but after discussing the possibilities at some length he decided that it might not have happened.

At our present position on the ice-cap we were flanked on both sides by mountains and were on the outskirts of the United States mountains. The following day we continued to climb steadily, and marked as our objective a far-off isolated peak due north of us. We had been forced to deflect our route westwards in order to avoid a mountain, but once past this we headed north once again. The mountain which we had chosen to march on was very prominent, and appeared higher than any others we could see. It stood lofty on the horizon, and as we drove along we both wondered what lay ahead of us over the skyline. Would there be good going, or would there be a barrier of fresh obstacles? We were very anxious indeed to stand on the summit of that mountain and know our fate. Along our route were no large crevasses; there were occasional loud reports beneath us, but only once did I go through the snow into a small crack, then only waist high. We drove up to the foot of the mountain in the evening and the visibility was very poor, the summit being completely clouded over. We made supper and waited, and a few hours later the clouds lifted; then we set out for the summit full of excitement. It was not a difficult climb, but we had to exercise a full measure of care on the steep ridges of hard snow, and there was much laborious step-cutting, especially on the last 300 feet, where the ridge had a razor-like edge. We arrived at the 9000-foot summit bathed in sweat, but we forgot all about that

when we looked out northwards over Grant Land. Beyond us stretched a great range of mountains, the summits of some of which must have reached a height of 10,000 feet or more, and on both flanks were also a multitude of mountains, smaller than those to the north of us. We settled down to study the country through the glasses, and the immediate result showed us that we would not hope to reach Cape Columbia in our present condition. The country ahead was extremely mountainous, calling for strong dogs, and an adequate supply of food for at least another week; and we had neither of these at our command. At our disposal was enough pemmican for another day of outward travel, while the human food was almost finished. We had been forced to feed more than the prescribed ration of pemmican to the dogs since they were ravenous. From our position on the mountain we could judge to what point another day would take us, and every inch of that ground we could study through the glasses. I listened to the opinion of the Eskimo, who said that the dogs could not go on farther in their present condition and with the meagre food supply available. There was also the return journey to consider through that valley of deep snow, and we did not wish to drive the dogs to death. We descended to our camp and slept, then early the next morning we climbed to the summit once more to make a last reconnaissance and take photographs.

It was a glorious day, not a cloud in the sky, and the sun was blazing down on the countless peaks ahead of us. Nukapinguaq pointed out to me through the glasses what he said was the sea-ice in Markham Inlet on the north coast at the edge of the polar sea. But as we stood in silence looking out over those mountains we knew we could go no farther and I most reluctantly made the decision to return to Lake Hazen. Gazing towards that mountain range for the last time, we christened it the "British Empire Range;" then after flying the Duke of York's Union Jack from the summit on which we stood, we turned our faces south once more. We had unfolded some of the mysteries of Grant Land, though much yet remains to be done. After penetrating the United States Range we had crossed over unknown country northwards reaching lat. 82° 25′. But we were burning for a future attempt and next time would be armed with experience and knowledge denied to us at the outset, which could only be obtained by pioneering.

The return journey to Lake Hazen was made in better time than expected, and at the end of the first day we camped at the foot of the glacier. The descent of the glacier was rapid and exciting; the ice at the foot was like polished glass. Sweeping down at a terrific pace the air rushed past us, and the sledge was ahead dragging the dogs along behind. The last 50 feet were on a very steep gradient, and we finished up in a heap at the bottom, Nukapinguaq following the sledge flat on his back and myself straggling across the load. After making camp the Eskimo made his usual search of the landscape through the glasses, and suddenly he reported a movement of caribou high up on the hills. He immediately went off to hunt them, and several hours later returned with the good news that he had shot three. What a vast difference it would have made if we could have seen caribou a few days before this! We made a meal off fresh steaks which he had carried in and then went out to bring in the remainder of the meat. When the dogs smelt it they went nearly crazy,

and made short work of their liberal feed; it was the first meat since the bear killed in Peabody Bay.

We decided now to try and reach the lake without another sleep, in order to get fish for the dogs as quickly as possible. The deep snow was again very tiring, but during the latter part of the journey we left the valley for the high land, which was a great improvement. After what seemed to us a short march we found ourselves looking down on the huge lake. We searched through the glasses for the camp where Stallworthy and Inuatuk would be fishing and failed to locate it, but after descending on to the lake and crossing it once in vain we eventually found them fishing on the north side. They had been fishing almost continuously since our departure, and had tried several localities with small success, obtaining only enough fish for a daily feed to their own dogs. Three arctic hares had been shot by Inuatuk, the first since leaving Etah. In days gone by this country was said to abound in hares, but that is not the case now and apart from musk oxen, which are preserved, all game is scarce. After another day at the lake we left for Fort Conger. The dogs were in dire need of meat; they had rested, but were still weak and hungry. We drove into Conger after travelling for two days, and the dogs were completely exhausted. The Eskimo had driven their dogs to the limit, hoping to see seal up on the ice in the harbour, but we were disappointed and were to wait a long time before getting seal. During this journey into Conger the dogs were almost incapable of pulling the sledge downhill, and Inuatuk was forced to shoot two of his.

Before making the long trek down the coast we rested for two days, and managed to scrape up a reasonable feed for the dogs by utilizing everything eatable in Amundsen's cache. In order to get down to the sealing country with all speed we abandoned one sledge at Conger and made up two large dog teams; Stallworthy and Nukapinguaq shared one sledge, Inuatuk and myself the other. Before leaving we deposited a record of our visit in Peary's hut. The crossing to the Greenland coast was made in good time and the wind had blown the snow harder since our previous journey. We now made full use of the small depôts of food which we had laid at intervals along the coast when coming north. These supplies, consisting of dog pemmican, skipper sardines, chocolate, biscuits, and coffee, proved invaluable since we got no seal until just north of Cape Calhoun. We had now run very short of oil and used seal blubber and wood for cooking purposes. It was a very slow and grimy job and Stallworthy, who generally cooked on it, would get up covered in black from the smoke. It was also noticeable at this time that the wooden boards began to disappear from the sledges, and—needless to say—into the blubber stove. Progress down Kennedy Channel was rapid; we knew now where the worst ice lay and avoided it by keeping well out in mid-channel. Just before Cape Calhoun Inuatuk got a large seal and the dogs enjoyed a good feed of meat. There was water now at the Cape, and we saw seal. We rested here for a couple of days, and made strenuous efforts to hunt dog food. The first evening the Eskimo brought in a small seal; they had a second one but it had drowned before they could reach it. When standing looking into the water we suddenly saw a very large seal come to the surface with a splash. The camp was in instant activity, and we sent shot after shot into that seal.

The Eskimo thought it would sink, but by a stroke of luck it kept afloat, drifting off shore to the far edge of the pool. Inuatuk climbed down on to the thin sea-ice, and tested his way carefully across to the other side. He arrived just in time to prevent the seal disappearing under the edge of the ice. Nukapinguaq was already down on a floe sharpening his knife, and as he cut up the meat Stallworthy and I hauled it up by a sealskin line on to the shore-ice 15 feet above. We had now about 600 lb. of fresh meat to feed our half-starved dogs. They ate and ate and we could see them swelling up; then at last they curled themselves up and slept for a day with lumps of meat lying untouched beside them. Our anxiety for the dogs was allayed for the present, and when we pulled out into Peabody Bay on the next day they showed signs of returning strength.

On leaving the shore for the sea-ice, one of the sledges went through the thin moving ice, but the dogs managed to keep pulling and we got it out without wetting the gear. Nearly all the dogs were sick the first day out, owing to their heavy feed, but later they went well. After two days' good going we were almost south of the Humboldt glacier once more, but at this stage were held up for a day by a blizzard. We got seal regularly now, and could rely on a daily feed for the dogs, which were steadily gaining strength.

On approaching Cache Point, the first depôt north of Etah, we were doubtful of getting round owing to open water. This would have meant going overland, but we managed to get round the point on the shore-ice. Smith Sound was now open water south of us on the Greenland side. We saw fresh sledge tracks here and concluded that the other parties had returned to Etah, and from this stage we followed their route back to the base. We had to negotiate two difficult places on the ice-foot, one being where the shore-ice had fallen into the sea, making it necessary to haul the sledges over a bare rock about 8 feet high. We learned later that Dr. Humphreys' party had met with an accident at this place. At Cape Hatherton we found a note from Shackleton telling us that every one had crossed the Sound safely. The last few hours overland to Etah were made in a severe snowstorm, the worst we experienced during the whole journey. While descending from the high land on to Foulke Fjord one of our sledges narrowly escaped disaster. Inuatuk and myself had just negotiated the steep snow slope and were standing talking on the shore-ice when we heard shouting from above. Inuatuk glanced upwards, then leapt aside crying to me to do likewise. A few seconds later a huge boulder landed on the ice and swept past the sledge, missing it only by inches; it had been dislodged by the other sledge, which was making the descent. Our winter quarters were now only a few hundred yards along the fjord, and as we drove into Etah our thoughts were intermingled with gladness to see old friends and sorrow in leaving the trail.

APPENDIX I: GEOLOGY

R. Bentham

The geological work of the expedition may be divided into two parts: that performed from the base (in the Etah district) and that done in Ellesmere Land during the spring sledging season.

Etah

Although several expeditions have wintered in the vicinity of Etah it was not until 1898 that a trained geologist, named Per Schei, made observations in that district. He remained in Foulke Fjord only for a day or two, as the *Fram* Expedition, of which he was a member, was bound for a more northerly destination. The same applies to the Canadian expedition, under A. P. Low, which visited Etah in 1903: and it was not until 1917, when Dr. Lauge Koch commenced his work in Inglefield Land, that any more systematic work was done. Since then the district has been visited by him on several occasions.

On either side of Foulke Fjord two plateaux occur, one at about 1000 feet above sea-level, due to peneplanation of Pre-cambrian eruptives, and another less extensive at 1800 feet. Farther south only one plateau is to be seen, at 800–1000 feet, the Pre-cambrian peneplane having been faulted down below sea-level. North of Etah, between the stream which enters the sea north-east of Refuge Harbour and the coast, there is only one plateau, namely the Pre-cambrian peneplane which maintains a height of about 800 feet. The two plateaux differ considerably in appearance. The higher is often capped by dolerite which is so shattered by frost action that walking over its surface is extremely difficult. On the other hand, the lower plateau is gently rolling with a few shallow lakes scattered over its surface and has been weathered to such a small extent that it may be said to be identical with the former Pre-cambrian scenery.

North-east of the stream mentioned above the country is of a different type, being lower and more extensively dissected. Except for two strips of country terminating in the projections of Cape Hatherton and Cairn Point the two plateaux seen in the vicinity of Foulke Fjord are absent, though the hills in the interior maintain a height of 1000 ft.

In the vicinity of Etah and to the south, streams show a tendency to follow fault lines, cutting deep narrow valleys which have a comparatively gentle gradient until the mouth is reached when there is a sharp fall. Owing to intensive frost action weathering is extremely rapid, and consequently the valleys are bordered with large accumulations of angular debris and the streams, however small, have extensive alluvial fans at their mouths. The coastal topography corresponds to that of the interior. The coast of the "plateau country" is formed of cliffs ranging in height from 400 to 800 feet, while the inlets are of the fjord type. The bays between Littleton Island and Cape Hatherton and between the latter and Cairn Point are very shallow and the coast is low lying. Where cliffs are absent, *e.g.* at the heads of bays and fjords, river terracing is often well developed. At the head of Foulke Fjord there is a series of seven terraces at heights of 40, 90, 125, 200, 290, 350, and 400 feet above sea-level. Towering above Etah there is another series of terraces, though only those at 290, 350, and 400 feet are well marked. On the south side of Foulke Fjord there are two examples of raised beaches. Terracing is common all along the coast of this part of Greenland, but by far the best example seen occurs to the north-east of Refuge Harbour.

As no work has yet been done on the specimens collected in Greenland, it is not possible to give more than a brief outline of the geology of the Etah district, and names given to rocks of igneous or metamorphic origin are merely field identifications. All the rocks in this district are of Pre-cambrian age and have been divided by Dr. Lauge Koch into two formations, the older "Etah Formation" and the younger "Thule Formation."

Etah Formation.—This formation consists of a complex series of igneous,

metamorphic, and sedimentary rocks. Collections were made in Foulke Fjord where the fjord walls are built up of a series of igneous rocks which have a dip to the west. Specimens collected between Etah and Brother John Glacier include varieties of diorite and an ultra basic pyroxene rich rock. There is a small outcrop of felspathic schist west of Reindeer Point. Between Sunrise Point and Cape Ohlsen there is a series of rocks with a vertical dip and an east–west strike. Sunrise Point itself is a cape of small elevation, made up of a garnetiferous quartz felspar gneiss. To the north this is followed by a biotite gneiss and this by a remarkably white rock which appears to be almost pure felspar, in which are included large lenticles of a very basic schist-like rock. This rock gives rise to some very striking cliff scenery, its whiteness forming a marked contrast to the rather drab rocks of the cliffs in the neighbourhood.

Other collections from this formation were made in the vicinity of Cape Hatherton. Here nearly vertical beds of limestone and arkose grit are to be seen in unconformable contact with a series of metamorphic rocks. These include several varieties of gneiss, mica schist, quartzite, and various types of ultra basic pyroxene rock. Collections were also made at a point outside the area under discussion, namely the deserted settlement of Anoretok to the north of Cairn Point. From this locality came samples of biotite gneiss, pyroxene felspar gneiss, and varieties of pyroxene rich rock.

Thule Formation.—The formation of that older series of igneous and metamorphic rocks was followed by a period of intense earth movements, which in turn was succeeded by one of peneplanation. After the formation of the peneplane deposits of shallow water and of desert origin were laid down. In the main these deposits consist of sandstones, some of which show a marked resemblance to the Torridonian of Scotland. A section south-east of Cape Hatherton showed 200 feet of brown sandstone together with beds of purple quartzose conglomerate, ripple marked sandstone, sun-cracked shale, and beds of indurated shale, banded olive green and brown. This is followed by a 50-foot dolerite sill and this by 75 feet of sandstone, containing beds with ripple marking and others with small veins of iron ore. Next comes another 50-foot sill of dolerite and then a bed of hard yellow sandstone, which forms the crest of the hill. Near Etah a Cryptozoon reef occurs near the base of this series.

The presence of Pre-cambrian sediments which are practically unaltered and still horizontally bedded emphasizes how free this part of Greenland has been from orogenic movements, since the beginning of Eozoic time. A number of comparatively small faults occur running in a general east-south-east–west-north-west direction, *e.g.* south of Foulke Fjord, where the Pre-cambrian peneplane is let down below sea-level by two faults: west of Etah where this peneplane is lowered from 1000 to 400 feet above sea-level (this by a north-west–south-east fault), and north of Etah, where it is let down even lower. The total resultant movement (since Pre-cambrian) seems to have been an upward one of about 2000 feet. It is of interest that at least 400 feet of this uplift has taken place in geologically recent times, terracing being common and streams showing rejuvenation. This indicates that Greenland is isostically recovering after the removal of the extra load of ice formed during the Quaternary Ice Age.

South-east Coast of Grinnell Land

Peary travelled up and down the Grinnell Land coast on several occasions but as his mind was set on reaching the Pole he rarely made any scientific observations. The first geological collections from this coast were secured by H. V. Fielden, the naturalist attached to the British Expedition of 1875–76.

He landed on the north coast of Bache Peninsula and at various points on the Grinnell Land coast to the north, securing fossils which indicated the presence of rocks of Ordovician and Silurian age. The only other geologist to visit this part of Ellesmere Land was Per Schei, who in 1899 collected fossils from the south and north coasts of Bache Peninsula and from Norman Lockyer Island, on the north side of Princess Marie Bay. He proved that Cambrian rocks were present on Bache Peninsula.

There are two types of topography in this area: the practically undissected plateau constituting Bache Peninsula and the typical Alpine topography which occurs north of Princess Marie Bay. The Bache Peninsula plateau maintains a height of 1200–1500 feet except for the depression connecting Harmsworth Bay and Flagler Fjord which scarcely reaches an elevation of 500 feet. Denudation has been almost negligible, streams being few in number and of inconsiderable length. The coasts of the peninsula are made up, except in very few cases (such as Police Detachment Bay), of high vertical cliffs. Harmsworth, Peary, and Bartletts Bays are the only major indentations. North of Princess Marie Bay the country is in a very advanced state of dissection, mountains of the saw-edge type being the predominant feature on the landscape, while some of the valleys attain considerable size and are often occupied by glaciers. In the vicinity of Scoresby Bay, where the ice-cap reaches to within a few miles of the sea, nunataks were seen the height of which was estimated at 500–600 feet above sea-level.

Bache Peninsula.—The abandoned Police Post near the mouth of Flagler Fjord was used as a base while work was being done in this part of Grinnell Land. From here trips were made to Cape Albert, Victoria Head and along Flagler Fjord into Harmsworth, Sawyer, and Woodward Bays. Archaean eruptives and metamorphic rocks outcrop in the cliffs between the mouth of Flagler Fjord and Cape Camperdown. Their upper surface has been peneplaned and on it rest beds of sandstone and conglomerate. In the vicinity of the Police Post the succeeding deposits consist of grey limestone conglomerate, grey flaggy limestone, limestone with "worm" tracks and some dolomite. Fossils were found at one locality and at one horizon only, viz. in one of the lower limestone beds in the ravine behind the Police Post. This limestone series has a general dip to the west, disappearing from the cliff section 4 miles east of the detachment. Four miles west of Cape Camperdown sediments again rest on the peneplaned surface of the Archaean rocks, though they differ in character from those at the equivalent level farther west. They have an easterly dip and consist of a current bedded red sandstone into which have been intruded two sills of dolerite. The sandstone is followed by a bed of massive dolomite, while the highest beds seen consist of flaggy limestone with "worm" tracks, similar in appearance to that seen in the ravine behind the Police Post.

Victoria Head was the next locality to be examined. The lowest beds seen, above the scree which extended 300 feet up the cliff, consisted of a light brown mottled limestone, yielding poorly preserved cephalopods. This is followed by limestone, grey and crystalline below, fissile, brown and black above. Limestone conglomerate and gypsiferous beds are present but their level could not be determined. Other fossils found included a gastropod similar to Euomphalus. These beds continued to the west as far as the eye could see. The cliffs in Harmsworth Bay are made up largely of a reddish brown limestone, having a perfectly vertical face. Fragments of this rock yielded gastropods. Above and below occur flaggy limestones, the upper of which yielded numerous fossil fragments, including orthid and other brachiopods, gastropods and free cheeks of trilobites, one of which was 6 inches in length. These beds lie unconformably

on the Flagler Fjord limestone and extend (with a slight easterly dip) along the north coast of Bache Peninsula, for a considerable distance, and also along the south coast of Sawyer Bay. A few fossils (including a crinoid head) were found in the latter locality.

Grinnell Land Coast North of Bache Peninsula.—Between Norman Lockyer Island and Cape Hawkes the coast runs parallel to the strike of the rocks in the cliffs. No collections however were made until Hayes Point was reached. Here grey flaggy limestones yielded fragments of trilobites and gastropods. Strata of a different type were seen between Maury Bay and Cape Norton Shaw, where the base of the cliffs is formed by an autoclastic breccia dipping steeply east-south-east. These beds yielded a rich fauna of cephalopods, together with trilobites, brachiopods, and corals, but few specimens could be extracted whole owing to the shattered character of the rock. These beds are overlain by limestone of a similar type, though it yields a fauna in which corals (*e.g.* Favosites, Halysites) predominate. Other fossils include cephalopods, gastropods, rhynchonellids and crinoid stems. These beds dip 30 degrees north and are unconformably overlain by a series of limestones, outcropping in Scoresby Bay, which dip 45 degrees north-west. Until more of the fossils collected have been cleaned and identified, the ages of the various limestones examined cannot be definitely determined. It can however be said that the trilobites found on the south coast of Bache Peninsula are of Cambrian type and the cephalopod limestone, occurring between Maury Bay and Cape Norton Shaw, is almost certainly Ordovician with apparently Silurian above.

Bache Peninsula has been little affected by earth movements since the peneplanation of the Archaean eruptive and metamorphic rocks took place. A number of small faults and anticlines do occur however running in a north-east–south-west direction. The biggest fault system in the peninsula has resulted in the formation of Harmsworth Bay. From Hayes Point to the south-west the strata are folded along an axis running parallel to the coast. The structure in the vicinity of Scoresby Bay is complex and until the age of the strata has been fixed, little can be said about the tectonics. As in the case of the Etah district, terraces are common though they fail to reach the heights attained by those on the Greenland side of Smith Sound, the highest observed being only 100 feet above sea-level.

Bibliography

Literature

Bugge, C. Petrographische Resultate der 2ten *Fram*-Expedition. Report No. 22. Kristiana 1910.

Koch, L. "The Geology of Inglefield Land." *Medd. om Grøn.* Bd. 73. Kobenhavn 1933.

Low, A. P. Report on the Dominion Government Expedition to Hudson Bay and the Arctic Islands on board the D.G.S. *Neptune*. Ottawa 1905.

Etheridge, R. "Palaeontology of the Coasts of Arctic Lands visited by the British Expedition under Capt. Sir George Nares." *Q.J.G.S.* 1878.

Holtedahl, O. Summary of the Geological Results. Report No. 36. Kristiana 1917.

Schei, P. Vorläufiger Bericht über die geologischen Beobachtungen auf der zweiten norwegischen Polarexpedition. Leipzig 1903.

Fielden, H. V., and C. E. De Rance. "Geology of the Arctic Lands visited by the late British Expedition under Capt. Sir George Nares." *Q.J.G.S.* 1878.

APPENDIX II: ORNITHOLOGY

D. Haig-Thomas

The ice conditions of 1934 prevented our landing in Ellesmere Island, and so destroyed my hopes of adding something to the ornithology of that country. Our winter quarters at Etah in north-west Greenland were not very interesting for an ornithologist, as MacMillan had spent four years there, and all the birds had been well described in 'Four Years in the Great White North.' I made a collection of eggs and skins, which are being worked out at the Natural History Museum, South Kensington, but the following are a few brief notes.

At the beginning of November, when the sun had set for the last time, there were still a few Wheatears (*Oenanthe oenanthe leucorrhoa*) by the lake at the end of the fjord. I very much fear that they left migration till too late, as I found two dead ones later on near the Base Hut. The Ptarmigan (*Lagopus rupestris?* subsp.), Raven (*Corisis corax principalis*), and Mandt's Guillemot (*Uria grylle mandti*) I either saw or heard in every month during the winter, and after investigation I found that the Ptarmigan crops contained willow buds, and that the ravens fed on the offal of foxes and dogs, but I was unable to ascertain on what the Guillemots lived which splashed about at the edge of the ice. I looked into the water from the ice-foot, but failed to see any plankton, on which they feed during the summer, and the edge of the ice in the vicinity of Etah is very dangerous owing to the prevailing off-shore wind. In February I saw a solitary Eider (*Somateria mollissima borealis?*), and others were reported at Cape York by the Eskimo in every month of the year.

On our sledge journey in Ellesmere Island the only birds I saw were Snow Buntings (*Plectrophenax nivalis*), Greenland Falcon (*Falco rusticolus candicans?*), and Ravens. Unfortunately we had to return to Greenland before the migratory season arrived. On our return to Greenland I travelled down over the ice-cap to McCormick Bay, where I spent the summer, and was able to add two new birds to North Greenland. These were the Lapland Bunting (*Calcarius lapponicus*), and the Golden Plover (*Charadrius dominicus dominicus*). The Golden Plover which was shot at Etah is the most northerly ever recorded, and the Lapland Bunting the most northerly in the American Continent. All the other birds which were observed I had been led to expect, but although I searched a great deal, I was unable to find the nest of the Greater Snow Goose (*Chen hyperborea atlantica*). The possibility of their nesting in Northern Greenland has long been suspected, though no nest has ever been found. A Goose that had been shot by an Eskimo was proved undoubtedly by examination to have been sitting, since all the down was plucked from the breast. I discovered a big colony of Knots (*? Calidris canutus*) in McCormick Bay, but was unable to find a nest. I estimated between thirty and sixty pairs bred there. Two White Fronted Geese (*Anser albifrons albifrons*), which the expedition obtained from Governor Rosendhal, were brought safely back to England, and though extremely weak when landed, are now doing very well.

APPENDIX III: CLIMATE

Edward Shackleton

We were advised by the Air Ministry not to attempt meteorological observations, on the grounds that these would be valueless, and we therefore confined ourselves to noting down weather conditions with a view to the number of flying days, and taking temperature observations. The suitability of Etah (78° 19′ N.) as a base has already been commented on in the general paper. On several occasions

winds reaching hurricane force blew for days on end, and although wind in the Polar Regions is usually associated with a rise in the temperature, the extremely cold katabatic winds blowing off the high Greenland ice-cap, in actual fact, lowered the temperature. These frequently blew at a time when it was quite calm outside the fjord. The predominating influence on the climate of this coast is the open water, which stretches from the edge of the main pack in Smith Sound, south to Cape York, and the pack of Melville Bay. This large expanse which retains a constant temperature of −29·2° F. only just below the surface, has a tremendously warming effect on the country. The edge of the main pack stretches across Smith Sound from about the latitude of Cairn Point, to Pim Island, and a few miles north of this the temperatures are very much lower, a fact which was noticed by all three sledge parties, and which is also borne out by the records of temperature observations taken at the former Police Station at Bache Peninsula in lat. 79° 04′ N., and the observations taken at Etah.

The dates of the departure and return of the sun are of course of paramount importance, but chronologically the seasons do not coincide with any of these dates. From a biological standpoint the autumn might be considered to extend from the beginning of August until Freeze Up, which occurs any time after the middle of September, although if the activities of the bird migrants are to be any indication it should last until the end of October. The winter period extends right through until the end of May or the beginning of June, and the spring or summer from the beginning of June until the end of July. Here again it should be mentioned that the first of the returning migrants, the Snow Buntings, arrived at the beginning of May.

To deal with our experiences: the fjord which had several times begun to freeze over towards the end of September, did not finally close to navigation before October 11, owing to the high winds which frequently broke up the ice. The sun appeared for the last time on October 24. The temperatures recorded for November were as follows:

	O.U.E.L.E.	MacMillan
Extreme maximum	18·5° F.	11·7° F.
Extreme minimum	−12·5° F.	−21·2° F.
Average maximum	1·1° F.	− 3·2° F.
Average minimum	− 2·2° F	−10·4° F.
Mean temperature	− 0·5° F.	− 6·8° F.

These were unusually high, as is shown by comparison with MacMillan's figures.

The coldest month on the expedition was February 1935, and the following temperatures for February and March may be of interest:

	February O.U.E.L.E.	*February* MacMillan	*March* O.U.E.L.E.	*March* MacMillan
Mean temperature ..	−15·9° F.	−15·8° F.	− 4·3° F.	−12·7° F.
Average daily maximum	−14·0° F.	−11·8° F.	− 1·5° F.	− 7·6° F.
Average daily minimum	−17·8° F.	−20·0° F.	− 7·7° F.	−20·0° F.
Absolute maximum ..	4·0° F.	4·0° F.	17·0° F.	10·3° F.
Absolute minimum ..	−37·0° F.	−29·5° F.	−25·0° F.	−32·1° F.

MacMillan's figures for the same months, which are the result of observations taken over a period of four years during the Crocker Land Expedition, may be of interest to compare with the figures given above.

The extreme minimum during our expedition was −37° F., on 4 February 1935, as against −42° F., occurring on 10 March 1914, the lowest during the four years of the Crocker Land Expedition.

During the months that the sun is absent the diurnal range of temperature is negligible, but the sun returns on February 18, and in March, when it is already well above the horizon, there is a distinct increase in the diurnal range, and although the minimums tend to remain about the same, as shown by MacMillan's records, there is a small but distinct rise in the maximums, as compared with February. Temperatures however still remain comparatively low until the last week in April, when a great change takes place, and by the end of May temperatures above freezing point are generally recorded. The expedition however was away from its base from the beginning of April, and north of the pack there was a distinct lag in the seasons, the cold weather being experienced until a later date. A temperature of −37° F. was recorded on April 6 only 30 miles north of Etah. It is necessary to emphasize that it is wind rather than temperature that has an influence on living conditions. This was particularly noticed by the various sledge parties. Temperatures of between 60 and 70 degrees of frost were quite comfortable for travel, but members of the expedition were sometimes frost-bitten in temperatures well above zero, when there was a wind blowing.

It is interesting to note that Bache Peninsula, which had been considered as a possible base for the expedition, is normally free from wind, and the chief obstacle to travel on that side of Smith Sound is frequently the deep snow which covers the sea-ice, a clear indication of absence of wind. Although the mean temperatures for the winter months are at least 15 degrees lower, it would have been more suitable for a base, if we had been able to reach it, than Etah, where the high winds that blow from the interior more than compensate for the higher temperatures. Robertson Bay and Thule however, which have temperatures similar to Etah, are comparatively free from wind, although rare but violent gales do sometimes take place, and certainly the former would be a more suitable place for winter quarters than Etah, especially in view of the fact that the glaciers there give a much easier access to the ice-cap.

Signs of thaw appeared towards the end of May and in early June. One of the boats was launched from the edge of the fjord ice about a mile away from the camp on June 15, and finally on July 11 the last of the ice floated out from a little bay opposite the camp. The first flower, the Purple Saxifrage, had been found on June 9. Although the sun had been at its highest in June, July was indeed the warmest month of the year, since at no time did the temperatures at Etah drop below freezing point, while the shade temperature was often above 50° F., and once reached 59° F. The mean for the month however was only slightly higher than the mean for the month of January in England, but owing to the abundant sunshine, and the very high radiation, due to the dryness of the atmosphere, the weather was extremely pleasant. Although the midnight sun did not disappear until October 24, it was already beginning to freeze fairly hard at night by the time the ship arrived on August 21, and as we headed south on the 24th the last was seen of the midnight sun.

APPENDIX IV: CLOTHING AND EQUIPMENT

EDWARD SHACKLETON

In the equipment of this expedition we were fortunate to have the most expert advice available, and we are particularly grateful to John Rymill in this respect. Sergeant H. W. Stallworthy, who had spent many years in the Arctic, was able to check up on all items of the expedition's stores, and in cases where opposing views were held by our advisors, we duplicated the equipment, in order that we might, under field conditions, find which was the most satisfactory.

Much has been written on the subject of animal skin versus manufactured clothing, and British explorers have, on the whole, preferred cotton wind-proofs and sweaters to coats of deerskin. During the Ellesmere Land Expedition, we were fully equipped with manufactured wind-proof garments of every description, and after fairly exhaustive tests, the members of the expedition all favoured skin clothing. There is no space here to give all the different reasons for this conclusion, and they have been put forward very clearly in Peary's 'Secrets of Arctic Travel,' and works by Stefansson and MacMillan. The most important factor is that clothing of deerskin is both lighter and warmer, and therefore, for winter and spring sledge journeys, more suitable. For temperatures above zero, such as are encountered by summer expeditions, cotton wind-proofs are entirely suitable, particularly so when the sledges are man-hauled. The main essential is to obtain the right kind of skins. These we ordered through the Greenland Administration, and they were from full-grown deer, autumn killed, whereas fawn skins are really necessary for satisfactory skin clothing. However we followed the example of the Smith Sound Eskimo, in whose country the caribou is now almost extinct, and who in consequence obtain their skins from Lapland through the Greenland Administration. Although their clothing is not quite as good as that favoured by the Baffin Land Eskimo, who rely entirely on caribou skin, it is however very satisfactory.

We wore sealskin boots with soles made of bearded seal skin (*Erignathus barbatus*), sheepskin stockings, and sometimes an ordinary pair of woollen socks. Between the sheepskin stocking and the sole of the boot a pad of grass, or failing this, a deerskin sole is inserted, and enormously increases the effectiveness of the insulation. The most important factor is to wear the minimum of clothing necessary rather than the maximum, since excessive warmth leads to perspiration, and therefore to frost bite. We usually carried also a pair of overshoes made out of either deerskin or bearskin, which were useful if ever the feet became too cold, as sometimes happened when camp was being made. The tops of the stockings were sometimes trimmed with bearskin, and above this was wound a band of sheepskin to cover the joining between breeches and boots. Those of us who were able to obtain them wore breeches of bearskin, which we found more suitable than the breeches made out of deerskin we had brought with us. Some of us also wore cotton or moleskin trousers, but these, on the whole, were not as warm and convenient.

In the coldest weather we wore deerskin hooded coats, known as *kuletas*, which were tremendously light and warm, but they were rather clumsy, owing to the nature of our skins. Wind-proof hooded coats of either Grenfell or moleskin, of which the hood and wrists were trimmed with fur, over an inner coat of duffle, were found satisfactory. Underneath, in the cold weather, we usually wore a small, cotton, hooded *anorak*, a Mackinaw shirt or icelandic sweater, and a couple of vests. Balaclavas were generally disliked owing to the fact that they are inclined to induce sweating round the neck. With a proper hood, an ordinary woollen knitted hat to cover the ears (preferably wool of a non-hairy nature), or better still a fur cap with ear pads, were found to be more satisfactory. Of the other items of clothing sealskin mitts with sheepskin linings were found to be satisfactory, though probably not as warm as dog or wolf skin. These should be trimmed with fur, which then fits against the fur trimming of the wrist of the sleeve. The result is much more satisfactory than the gauntlet type of mitt. A pair of woollen gloves is sometimes useful for untangling the dog-lines or for doing odd jobs for which the fingers are necessary. But generally speaking by separating the fingers gloves tend to reduce the warmth of the hand, even inside a mitt, and for ordinary purposes should not be worn at all.

The conclusions with regard to clothing were arrived at as a result of the experiences on the recent expedition, and an exchange of views both with Sergeant H. W. Stallworthy, who knows both the eastern and western Arctic, and also with Mr. T. H. Manning, who had been in Southampton Island. When proper fawn skins are available, undoubtedly the clothing of the Baffin Land Eskimo is the most perfect for Arctic travel. This consists almost entirely of deerskin, with underwear made out of the same material. Sealskin boots are relegated to summer wear only. Where possible the clothing should be made and sewn in the country by the native women, and owing to the fact that the women outnumber the men in the Canadian Arctic, the sewing is considerably better done there than among the Smith Sound Eskimo. Thus their sealskin boots, which are most carefully double-stitched, are much more watertight.

With regard to sleeping-bags there is no question that deerskin bags are warmer and lighter, but they require a good deal more attention for purposes of repair than an eiderdown robe, and are more liable to sustain serious damage. An eiderdown robe which has been dropped in water can be dried out, but a deerskin bag may be finished by such treatment, and on the advice of John Rymill, who equipped his expedition similarly in this respect, we carried heavy eiderdown robes. In our case these were made for us by Messrs. Thomas Black, of Greenock. In very cold weather we had an additional lighter sleeping-bag, weighing 2 lb., which could be fitted into the big one, but in practice a single bag was enough. Undoubtedly increased insulation results from the application of this practice of having two light bags instead of one heavy one. We had a heavy drill cover of a special design fitted over the whole of the sleeping-bag, so that it enclosed it when unrolled, and enabled us to roll it up very quickly in the mornings, as well as increasing insulation and preventing snow from getting in, either when on the trail or in a snow iglu. A sealskin, and on top of that a deerskin, provide ample insulation for a sleeping-bag from the cold of the ground or ice.

Tents.—We had several designs of tents on the expedition, and the general opinion seemed to be that our double pyramid tents, which were made for us by Messrs. Black of Greenock, and which were similar to the Watkins tent in design, were the warmest. One party used a single tent to hold the four of them with apparently complete comfort, and certainly increased warmth. Although snow iglus undoubtedly have great advantages, particularly during a blizzard, we generally used our tents. Against the extra weight of carrying a tent must be set the length of time necessary to build an iglu for each night's camp, and although the latter are very suitable on a trail which is to be used frequently, a two-hour wait before one can get into one's sleeping-bag at the end of a long day's march can be a very trying experience. On the other hand, when sledging with Eskimo it is probable that, being more skilful dog-drivers, at least one man may have driven so far ahead that the camp is sometimes half finished by the time the European members of the party arrive. Conditions vary tremendously of course in different localities, and the most skilful iglu builders are to be found in Baffin Land. Suitable snow for iglu building is not always available, and since in ideal conditions the blocks should be cut with a saw from a drift in which the snow is of an even consistency, the ideal snow conditions are the exception. A snow bench a couple of feet high usually fills just over half of the circular iglu, and on this are placed the sleeping-bags, on top, of course, of the sealskin and deerskin. The primuses are placed on the ground, and thus the members of the party are best situated to get the full benefit of the heat from the stoves. If the iglu is to be used for any length of time, it is possible by pegging a canvas or sealskin lining inside the roof to raise the temperature of the

iglu to any height desired, without melting it. This is the method adopted by Eskimo in their winter hunting camps, and they even contrive windows with blocks of fresh-water ice, taken from a lake or glacier. It is of course necessary to have a small hole in the roof for ventilation. To any one reasonably competent at manual work it is not at all difficult to learn to build a snow iglu, and certainly Stallworthy could produce one almost as good as any Eskimo's. All the equipment necessary is a saw and a snow knife. Several other members of the expedition were also able to build iglus.

Another considerable advantage is the fact that there is in an iglu none of the flapping which is so trying in a tent during a blizzard, nor can the finished house blow away, as has sometimes occurred during recent expeditions. Indeed, to be able to build an iglu is an extremely important, in fact, almost an essential qualification for an Arctic traveller, since then he has almost always the certainty of a shelter if he is caught out in a storm.

APPENDIX V: DOGS AND SLEDGES

EDWARD SHACKLETON

It is impossible to come to conclusions on the subject of sledging technique which would be universally applicable. There is a very large difference between the sledging methods which would be suitable for the western Arctic, for the Greenland ice-cap, and for the polar pack. Most of our sledging operations took place over the last named, and in order to withstand the tremendous battering that a loaded sledge has to endure amid the rough ice and pressure ridges of the polar pack it was necessary to use the heavy North Greenland sledge, or *komatik*, the main features of which are the solid runners and the absence of struts underneath the flooring, thus facilitating travel in deep snow. We had however taken with us some light Nansen sledges which had been built under the care of Captain Ejnar Mikkelsen, and although these were suitable for use on the comparatively smooth surface and deep snow of the inland ice-sheets they were not nearly strong enough for the sea-ice. Of the seven sledges scarcely one of them even survived the sledging which took place in the Etah district, where the ice was not very rough. One thing is important in the design of these light sledges, and that is that not only should they be tremendously resilient, but they should be of the simplest design. Reliance should be placed primarily on bindings rather than on metal strengthening, since the binding is always easy to replace, and in the event of a serious smash the binding should give before the wood is broken. Although this may cause an occasional extra repair the sledges will last longer in the end. This principle was applied to the solid-runner sledges which we used on the sea-ice. The uprights or handlebars were lashed very firmly with sealskin line to the runners, so that in the event of a serious crash, in which for instance the sledge might land upside down, the bindings always gave first, and so the handlebars thus avoided being smashed. Our runners, which were about 11 feet long, were made of heavy Victoria Ash, $1\frac{3}{4}$ inches thick and about 9 inches in width. Although the wood was perhaps a little on the heavy side these sledges were found by the majority of the expedition to be very satisfactory. The Eskimo themselves tend to have shorter and lighter sledges for use in their fjords and bays, but for big sledge journeys, especially when rough ice is to be encountered, a long sledge will ride far better and will give much less trouble in the long run: an opinion endorsed also by T. H. Manning. The Baffin Land and Canadian Eastern Arctic Eskimo use even longer *komatiks*, without handlebars and with mud-runners. For travelling however over pack-ice the handlebars are invalu-

able for pushing the sledge from behind. In fact when a heavily loaded sledge is jammed between broken ridges of ice it is even necessary to lift it from behind, a feat which would be impossible without handlebars.

The sledge runners were shod with steel shoeing, specially cast and tempered for the expedition by Messrs. Firth and Brown, and these were very satisfactory. It is important not to have sledge runners which are so hard that they are impossible to file smooth. We had also some broad metal sledge runners which were meant for use on the Nansen sledges, and some of the Eskimo fixed these to their narrow solid-runner sledges. The results on the whole were satisfactory, but in very low temperatures, when the snow rather resembles sand in consistency, there is a good deal more friction, and the sledge pulls less easily. Undoubtedly the narrower runners give more satisfactory results in very cold weather, provided deep snow is not encountered, when of course the broad Nansen type is more satisfactory. Sometimes too, when there is a thin covering of snow on the ice, the narrower type of runner cuts right through to the sea-ice and run more easily on that than the sledges with the broad metal runners. On smooth hummocks, such as are encountered on palaeocrystic ice, or on the ice-foot, the broad runners have much more tendency to sideslip, and a sledge thus equipped is, in inexpert hands, much more difficult to manage. In certain circumstances indeed, when for instance travelling along a narrow ice-shelf at the edge of open water, with only an inch or two's margin between safety and disaster, it may be definitely dangerous. We found it easy for one man to drive a sledge over the fjord or over ice-cap, but when picking a way through rough ice or along a narrow ice-foot, no white man can have anything like the skill of an Eskimo. It would certainly take one or even two years for an ordinarily competent person to learn to handle a sledge by himself in the conditions encountered on our sledge journeys without causing unnecessary delays. In addition the white man usually has the initial disadvantage of a scratch dog-team. In fact the secret of polar travel which made Peary, MacMillan, and others so successful, was that they relied primarily on Eskimo for their main transport. MacMillan however is one of the few men whom the Eskimo say was almost as good a dog-driver as themselves. Even Stallworthy, who spent over thirteen years in the north, could not handle a team with anything like the efficiency of an Eskimo. As the Smith Sound tribe are indeed keen travellers and to some extent interested in exploration, future expeditions would do well to rely on them for their transport. However we found that we obtained satisfactory results by putting two white men to a sledge, an arrangement which was all the more necessary since our teams had not been bred and trained together. Although the dogs were as good as could be obtained, a team containing fourteen dogs was necessarily made up of rival groups, and as each dog was on a separate 16-foot line, considerable skill in driving was necessary, one requirement being the ability to handle a 35-foot whip. In consequence our three sledge parties were each made up of two Europeans, with four Eskimo, two of whom acted as support Eskimo, and were sent home early, with a total of five sledges in all, and about sixty dogs. One great advantage that results from this method of putting the two white members of the party to one sledge is that it ensures under ordinary conditions that one man is free to leave the sledge either to take photographs or, in the case of Bentham, the geologist, to examine any promising-looking rocks which might be observed if the route lay close to shore. In addition, when the ice is smooth, and there is deep snow, the spare man can break trail ahead of the dogs, and as they always pull better with a trail to follow, this is sometimes an important factor.

Our dogs were attached to the sledge by what is known as the Fan system,

which is the only possible method of travel in rough sea-ice. Although the pull tends to be slightly less direct than the Tandem or Nome Hitch it is the only technique which is possible amid the very rough ice and pressure ridges of the sea-ice. It enables each dog to pick out its own route, and so avoid the fate that would overtake it in Tandem, of being strung up in the air across a small chasm in the ice, while the leader on a single line pulls ahead. In the Fan system each dog has its own trace which may be anything from 10–16 feet long, and this trace is attached to the main draw line, which is secured to the sledge by an ivory or bone ring. At the other end of the trace there is fixed a swivel, which is an absolute essential to this system. To this is joined a small piece of sealskin line, 2 or 3 feet long, which is tied to the dog's harness. There are several great advantages in this. The small piece of line, which is naturally not nearly so valuable as the main trace, can be easily shortened or a longer piece can be substituted, and so the total length of the dog's line can be adjusted without damaging the main trace. Again, when it is necessary to loose the dogs rapidly, as for instance for a bear hunt, it is possible to cut the small piece of line and still leave the main trace intact. Those dogs also which chew their lines are more inclined to chew the piece nearest to them, which is thus easily replaced. The best type of line is undoubtedly sealskin (Ookjuk, *Erignathus barbatus*) both for strength and ease in untangling. When first cut from the seal it is inclined to be stiff, and consequently brittle, and in order to make it pliable enough for use it is necessary to chew it well, and then stretch it. A line also that has become stiff and hard through drying out too thoroughly can be to some extent restored by this method. It is certainly much easier to untangle than rope, which will absorb any moisture, freeze hard, and break very easily, as well as being about four times more difficult to untangle. Sealskin is also the best material for dog harness, but like sealskin line it has the great disadvantage of being edible. Lamp wick is a very good substitute, but has the disadvantage of freezing very easily, when it is liable to chafe the dog. In order to guard against the dogs chewing their lines the Smith Sound Eskimo always knock out their dogs' molars, which seems an extremely cruel practice, but it certainly does reduce the number of chewed lines, which on a long and hungry sledge journey may become a very serious problem. Another method of avoiding this difficulty is to tie the dogs up on rope lines at night, and although they frequently chew themselves free, they do a great deal less damage with this type of line. It should be possible however to find some substitute material which would possess the qualities of sealskin without its attraction as food to the dogs. When travelling over sea-ice the dogs are very easily secured at night by a handle which is cut in the ice and which acts as an anchor. For a permanent anchor at for instance the base camp a loop of rope fixed to a board dug into the ground will be easily secured by pouring water over it; this at once freezes it solid.

It is very difficult to decide what is the best number of dogs for a team. For ice-cap travel small teams seem preferable. Peary had teams of eight dogs on his polar trip, but the majority of the Eskimo with whom we talked preferred at least ten dogs for a one-man team, and if they were to be two to the sledge fourteen dogs did not seem excessive to them. In fact some of them preferred even more than that, and one of the best dog-drivers in North Greenland, who accompanied Stallworthy on his search for Dr. Krueger, had twenty-one dogs in his team. Although the speed and the load may be increased by having a large team, a great deal of extra food has to be carried, and in completely barren country a big team may be rather a mixed blessing. On the other hand, certain parts of the Canadian Arctic are very rich in game, and during the late Inspector Joy's famous Melville Island journey, in which he covered over 1800 miles in

less than three months, there was no serious shortage of food, and it was not necessary to shoot the dogs. Incidentally Inspector Joy, himself a very experienced traveller, travelled as a passenger, his driver being Nukapinguaq, our chief Eskimo.

With regard to the general welfare of the dogs, problems connected with this are chiefly concerned with feeding, and this, in the main, is a question of giving them enough to eat. One thing however it is important to stress, and that is that dogs accustomed to one type of diet may not thrive on another. Thus dogs which have been fed on dried fish may be completely upset by a diet of fresh walrus meat. This is particularly noticeable in the change over from walrus or seal meat to pemmican, which consists of dried beef and fat. Amounts should vary according to the time of year, and the amount of work being accomplished. On spring sledge journeys, when the dogs consume much more energy, not only owing to the cold but also owing to the greater friction offered by the snow at low temperatures, they would require at least 1½ lb. of pemmican a day over a long journey. There is also a limit to the length of time for which dogs can be maintained in full strength on food that lacks the necessary vitamins.

At the base camp our dogs were fed on frozen walrus meat and dried fish, which we had obtained from West Greenland. Unfortunately some of the fish sacks contained shark flesh, some of which was poisonous, and as a result we lost a number of dogs. We cached our walrus meat under rocks, which is the usual Eskimo method of protecting anything from foxes, but unfortunately one of the depots was raided by a bear, against which rocks are no protection, and a good deal of damage was done. We also had to feed a number of dog teams belonging to visiting Eskimo, so at one time there was rather a food shortage, and we were forced to concoct various stews of porridge, rice, and Sanatogen mixed up with dog fat. Before starting on the sledge journeys we fed some of the Bovril Dog Pemmican which helped the dogs to get accustomed to it.

For shelter during the winter we built wind-breaks with boxes, and even snow iglus, but the Eskimo dogs are remarkably hardy. Some of the weaker ones however did not stand up very well to the continuous gales at Etah, which must certainly be one of the severest places in the world for dogs to winter in. There is however one general conclusion which is universally applicable, and that is the necessity of giving the maximum attention to the dogs. At night for instance when a dog starts howling it may be necessary to go out and see whether a line is twisted round one of its paws. For negligence in this respect may mean a severe frost bite, and loss of the dog. Although it is essential to maintain good discipline in a large team it is equally possible to be on very friendly terms with all the dogs, and every precaution for their comfort and well-being during the winter night is amply repaid on the sledge journeys.

APPENDIX VI: BOTANY

A. J. Wilmott

The expedition left Ellesmere Island too early in the year for any phanerogamic plants to be collected, but a considerable collection was made in N.W. Greenland by Dr. Noel Humphreys, who dried (up to six sets of) everything met with around Etah (Foulke Fjord; "Inglefield Land"). This collection is being worked out by me at the British Museum, and should be a valuable addition to our knowledge of the flora of that area, where a few plants were also collected in July 1875 by the Nares Expedition on the *Alert* and *Discovery*.

In addition to all the flowering plants seen near Etah during a whole flowering season, specimens are included from Cape Alexander, Hatherton Bay, Robertson

Bay, and head of Foulke Fjord. Mr. D. Haig-Thomas assisted with some collections at Cape Hatherton; while plants were also collected at Disko and Jakobshavn in August (Haig-Thomas) and September (Humphreys). Altogether about three hundred numbers of well-collected and dried specimens are available for study, a list of which will be prepared in due course.

A. W. Moore made a small collection of marine animals by dredging at depths between 20 feet and 70 feet in Foulke Fjord, Etah, in July 1935. These specimens are deposited in the British Museum (Natural History). They include mainly Crustacea, Echinoderms, small fish, and a few Mollusca. A report will be issued later.

DISCUSSION

Before the paper the PRESIDENT (Major-General Sir PERCY COX) said: We have a full evening and so I do not propose to keep you long with my opening remarks. It is an honour and pleasure to us to have the Danish Minister here, and also Colonel Vanier, representing the High Commissioner for Canada. You will realize as the evening goes on how grateful the lecturers are for the help and cooperation they received from those two governments.

The title of the lecture is "The Oxford University Ellesmere Land Expedition." The leader was Dr. Noel Humphreys and the organizer Mr. Edward Shackleton. Dr. Humphreys will lead off and be followed by Mr. Shackleton and the other members of the Expedition.

As regards Dr. Humphreys you will doubtless remember him for his two papers upon the work he did on Ruwenzori. He was awarded the Murchison Grant two years ago for his work there. Edward Shackleton I need hardly introduce. We have the statue of his father close to us on the outer wall of this hall. He was the organizer of the expedition in consultation with Mr. Charles Elton, and both he and his comrades will, I hope, each have a few words to say about the part which they severally played in the expedition. They decided to split up into three parties in order to take full advantage of their opportunities. They have some splendid slides to show us.

Dr. Noel Humphreys, Mr. Edward Shackleton, and other members of the expedition then contributed to the record printed above, and a discussion followed.

The PRESIDENT: We have the great pleasure to-night of the presence of H.E. The Danish Minister: and I want to ask him if he will say a few words.

H.E. THE DANISH MINISTER: It has given me the greatest pleasure to be present to-night to listen to the very interesting remarks by Dr. Noel Humphreys, Mr. Edward Shackleton, and their brave comrades. I have been especially touched by the very kind words that have been uttered concerning our colonization of Greenland and the help extended to the expedition by the Danish Government. It has become the tradition under the auspices of the Royal Geographical Society that Great Britain and Denmark should work hand in hand in Arctic exploration, and it is my hope that this cooperation will continue for many years to come.

The PRESIDENT: Colonel Vanier, would you say a few words ?

Colonel VANIER: In the first place, I should like to bring you a message of regret from the High Commissioner for Canada who is unable to be present here this evening. He would have wished to welcome in person the members of this expedition back from their successful work in Arctic Canada.

I had the good fortune to be at St. Katherine's Dock when the *Signalhorn* left, and I almost jumped aboard. I believe that if there had not been a physical

disability to prevent it I might have been tempted to leave my work and my family. It gives me therefore particular pleasure to welcome back from that expedition Dr. Humphreys, Mr. Shackleton and the other members. They have spoken of the debt that they owe to Canada: I should like to say that if a debt is owed at all it is by Canada to them; and I should like to pay to them a tribute of gratitude and of admiration.

You will have noticed that the Danish and the Canadian Governments are always willing to cooperate in matters of exploration, even though at times they may be rivals in the field of live-stock or its products. If the expedition had not made use of pemmican I should not have dared, because it would have been indiscreet, to ask Dr. Humphreys and Mr. Shackleton whether they had carried Danish or Canadian bacon!

I have learned a great deal to-night. I have learned that Ellesmere Island is, or might be, an asylum for retired policemen! I have also heard of a most interesting game—burnt-cork patience—that I am going to try to teach my children. But there is one thing that the members of this expedition did not tell us, and it is something that I happen to know: that they used extraordinary self-restraint when dealing with the musk-ox which you saw on the screen. They were sporting enough never to shoot one of them, although at times they must have been sorely tempted to do so because the dogs were hungry.

My last word is this: when they go back to Ellesmere Land—and they are going back, because all explorers are either out on an expedition or speaking about it for a very short time and then preparing for another expedition—when they go back I am sure that they will have the whole-hearted support of the Canadian Government, and we shall see whether it is not possible to obtain permission to shoot a few musk-ox.

The PRESIDENT: Dr. Mill, we should like to hear you for a few minutes.

Dr. H. R. MILL: Of the many charming and delightful evening meetings which take place in this hall I think you will agree with me that none has given rise to greater pleasure or more admiration for the speakers than this to-night. We have grown accustomed to bright descriptions of their achievements by the young men from the Universities of Oxford and Cambridge, and to-night seems to suggest that perhaps, of the two, the dark blue team is the more light-hearted. I do not think I have ever heard in all the many meetings of this Society so much good nature in the description of hard experiences in a difficult country and such an amount of mirth in the audience at pictures, which have rarely been excelled in beauty or aptness.

I will not praise the individual speakers, though I must express gratification at seeing my young friend Shackleton following so happily in the footsteps of my old friend, his father. But there were feelings in my mind, going back to the memory of earlier expeditions to that wonderful Ellesmere Land, which we saw to-night as a place of flowers, where snow-buntings went for no other purpose but to fly about and enjoy themselves. In the old days the stories from Ellesmere Land were of a grimmer kind. I remember well as a boy reading of the difficulties that beset the last British Naval Arctic Expedition under Captain Nares in the *Alert* and the *Discovery;* and just fifty years ago this week I heard Lieutenant A. W. Greely describe the achievements of the American party during the three hard winters they spent at their base at Fort Conger and on their return journey which only a few survived.

It is a curious thought that Greely lived long enough to hear about this latest expedition to Fort Conger, for he only died last month in his ninety-second year —a rare age indeed for Arctic explorers. But from what we have heard of the proceedings of the Oxford University Expedition I look forward confidently to

those young men going back and back again until they finish their work and perhaps reach an age as great as that of Greely himself.

The PRESIDENT: There are two expressions of regret that I wish to convey to you. The first is that Lady Shackleton and her daughter have not been able to come to-night, Lady Shackleton being unfortunately not well enough. The second is that Sergeant Stallworthy is not here. As you have heard, the members of the expedition have all paid great tribute to his fine qualities and the help they received from him during the expedition. As to the expedition itself, the party had every sort of ill-luck in the way of weather and ice conditions to start with. But in spite of being kept the whole winter at Etah, whereas they had hoped to have been on the Bache Peninsula, they accomplished really valuable work, locating a new range of mountains between United States Range and the Arctic Ocean. I very much hope that they may find it possible to organize another attack on it, with the knowledge that they will have a fine piece of discovery to their credit, if they succeed.

I should like, in conclusion, to thank all the speakers who have been good enough to come to-night, and to ask you all to join me in thanking members of the expedition for a most interesting and instructive evening.

THE GLACIATION AND SOLIFLUCTION OF MINYA GONGKAR: *A paper read at the Afternoon Meeting of the Society on 10 February 1936*

PROFESSOR ARNOLD HEIM

UNTIL the year 1930 practically nothing was known of the eastern Tibetan frontal ranges and of the highest mountain of China, here called Minya Gongkar. This holy mountain was first designed and measured on long distance by Kreitner of the Szechenyi Expedition [1] in 1877–80 under the name of Bokunka. The height was determined as 7600 metres. Forty-five years later the missionary J. H. Edgar,[2] apparently not knowing of this observation, published a rough sketch from the same point at Yinkwantshai, and called the mountain Gang ka.

The excellent map of Yünnan by Davies 1906 [3] does not show the glaciated frontier wall, and the Map of India only gives the name Mount Koungka.[4]

In 1929 J. F. Rock,[5] on behalf of the National Geographic Society of Washington, made the first photographs from the western side of Minya Konka. The result of his measurements is 25,600 feet or 7800 metres. The following year H. Stevens, of the Roosevelt hunting expedition, published his 'Sketches of the Tatsienlu Peaks.' [6]

After Rock followed the writer's expedition [7] of 1930–31, and the admirable ascent of the summit by Burdsall and Moore of 28 October 1932.[8] Their book contains numerous careful measurements and photographs of geographical importance.

Professor Ed. Imhof, of the writer's expedition, by photogrammetric surveying came to an elevation of 7700 metres for Minya Gongkar, while Burdsall and Emmons, by direct triangulation, found 24,900 feet (7590 metres). If we consider that all measurements are based on barometric pressure, the differences for such a remote region are not surprising. The figures given by Rock seem to be all too high. If we accept 7600 metres, we will not be far off.

Besides the writer's book 'Minya Gongkar,' which in his opinion gives the correct spelling, several papers and reviews have been published, amongst which a few are cited below.[9] The aim of this paper is to give a general view

[1] 'Die wissenschaftlichen Ergebnisse der Reise des Grafen Szechenyi in Ostasien.' Wien, 1893, Bd. I.

[2] Journal of the West China Border Research Soc. Chengtu, 1922/23, p. 58.

[3] Major H. R. Davies, Map of Yünnan 1 inch to 20 miles (1 : 1,267,200).

[4] Map of India 1 : 1,000,000 Sheet No. 100.

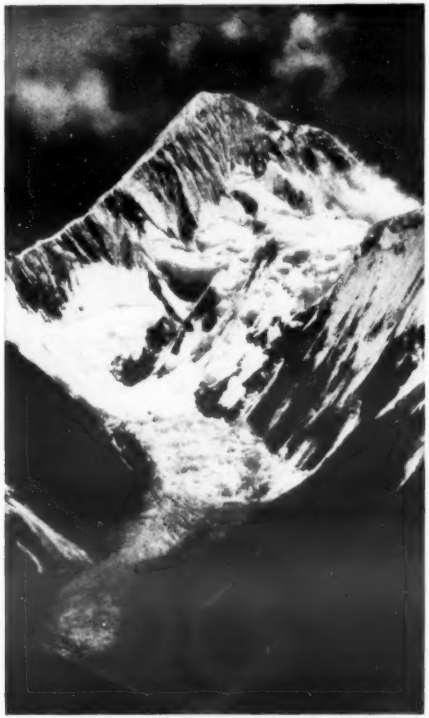
[5] J. F. Rock, "The Glories of Minya Konka." *Nat. Geogr. Mag.* October 1930.

[6] *Geogr. Jour.*, vol. 75, p. 345.

[7] Arn. Heim, 'Minya Gongkar, Forschungsreise ins Hochgebirge von Chinesisch Tibet.' With 26 designs, maps, panoramic view and 146 photos, amongst which 6 plates in colours. Hans Huber, Bern.

[8] R. L. Burdsall and A. B. Emmons, 'Men against the Clouds. The conquest of Minya Konka.' Harper and Brothers, New York and London, 1935.

[9] Arn. Heim, "Szechuan–Tibet Expedition der Sunyatsen Univ. Canton." *Zeitschr. d. Ges. f. Erdkunde*, Berlin 1931. "The structure of Minya Gongka. Preliminary sketch." *Bull. geol. Soc. of China*. Peking 1931. Tectonical sketch of the Yangtse



1. Minya Gongkar (7600 m.) and Small Gomba Glacier, from W.

2. Polished granite at knee of Hailoko Glacier, looking E.

3. Dirty block-ice at mouth of Great Gomba Glacier, 3800 m.

4. Great Gomba Glacier: Mount Chu (6500 m.) on left and Nyambö (6200 m.)

5. Minya Gongkar and Gomba Glaciers from the west

6. Stratified ice with cleavage and diagonal bands, Great Gomba Glacier

on the glaciation, while the main geological work with a geological map will follow later.

The present glaciers

The main glacier on the west side is the Great Gomba Glacier. It was first photographed by Rock and called by mistake Nyambö Glacier. The ice is collected on the south side of Minya Gongkar. The stream has a length of about 10 kilometres. The tongue is only 2 kilometres north-east of the monastery Gongkar Gomba, at 3800 metres above sea-level (Pll. 3, 4).

The Small Gomba Glacier derives from the north-west side of Minya Gongkar and joins Great Gomba Glacier at nearly a right angle without contributing to it. It is cut off by the greater neighbour. Both Gomba Glaciers are largely covered with blocks, especially of granite from the highest peaks. Several small green lakes are found on the surface of the moraine-covered ice stream.

On both sides the ice tongue is separated from the slate rock by deeply cut V-shaped glacial streams. The one to the south partly runs on ground moraine and is cut 100 metres deep below the middle part of the glacier. It seems that the glacier is overriding its own ground moraine, unable to remove this abundant detrital material.

The glaciers on the north and east side of Minya Gongkar were discovered by the writer in 1930, the eastern one being the largest of all the glaciers of the range, and the only one which extends down into the forest region.

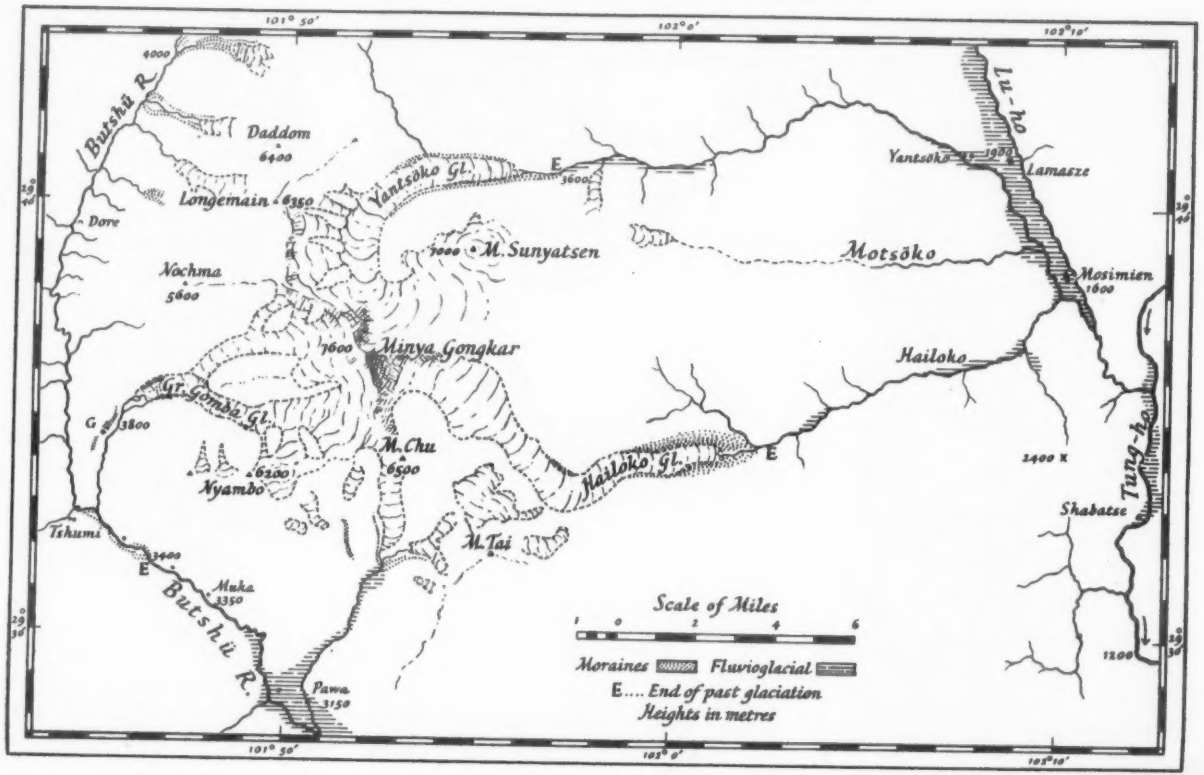
The Yantsöko Glacier derives from the great snow trough between Minya Gongkar and Mount Sunyatsen (7000) and bends around like a snail towards west, then to north and east. A tributary stream of 3–4 cubic metres per second coming from the valley in the north-west falls into a cave of ice and comes out again at the glacier foot 3–4 kilometres farther down, together with the melt-water of the Yantsöko Glacier. In contrast to the Gomba Glaciers, the side moraines are well-defined crests with sharp scarps towards the glacier, 10 to 20 metres in height (Pl. 7, left side). They are probably of pleistocene age.

The Hailoko Glacier has a length of about 16 kilometres and reaches the fir-tree jungle in the shape of a rounded tongue (Pl. 10). It has two ice falls, one just below the knee (Pl. 10), and a larger one with a strongly convex surface of some 500 metres drop in the upper part (Pl. 11). Like Yantsöko, it is accompanied by pronounced ridges of old moraine which are scratched by the actual ice flow. Some very pretty glacier tables are found in the lower part. The glacier gate is surrounded by jungle of firs, beeches, and rhododendron. On account of broken instruments, the elevation could not be measured, but is guessed as about 3000 metres or less.

The next largest known glacier of Gongkar Range is the Djaze Glacier (Pl. 14), 20 kilometres north of Minya Gongkar. Adjoining it is the Reddomain Glacier (Pl. 9). The supposed glaciers on the east side of Djaze Gongkar

from Ichang to the Red Basin. Geol. Survey of Kwangtung and Kwangsi, Spec. publ., No. XIV. Canton 1933. "The Batholiths of Minya Gongkar and Lamoshé, Chinese Tibet." *Eclogae geol. Helv.* 1934.

Albr. Penck, "Minya Gongkar." *Zeitschr. d. Ges. f. Erdkunde* 1934.


101° 50'
102° 0'
102° 10'
29° 40'
29° 30'
Butshü R.
4000
Daddom
6400
Longemain
6350
Dore
Nochma
5600
Yantsöko Gl.
E
3600
7000
M. Sunyatsen
Minya Gongkar
7600
Gr. Gomba Gl.
G
3800
M. Chu
6500
6200
Nyambo
Tshumi
3400
E
Muka
3350
Butshü R.
Pawa
3150
M. Tai
Hailoko Gl.
E
Yantsöko
1900
Lamasze
Motsöko
Mosimien
1600
Hailoko
2400 x
Shabatse
1200
Lu-ho
Tung-ho
Scale of Miles
1 0 2 4 6
Moraines
Fluvioglacial
E.... End of past glaciation
Heights in metres

are yet unexplored. Little also is known of the glaciers between the Tatsienlu Peaks (Lamoshé Glacier, Tatsienlu Glacier, see map 1 : 275,000 in 'Minya Gongkar').

Snow fall and hoar ice

In the upper region the snow falls chiefly during the later part of summer and in autumn, especially in August, September, and October. September seems to be the worst month for travelling. For months the mountains were hidden in clouds. During winter we had only one snowfall of importance, namely on November 22. It was snowing again a little on January 14. Some more snow may fall in early spring. As a whole the winter is dry and clear, and little, if any, snow is found on the Tibetan highland behind the great front ranges. As already pointed out by Edgar, the summer floods of the Yangtse cannot derive from snow melting in the interior, and they are connected only to a very small extent with ablation of ice and snow of the Tibetan front ranges.

Hoar ice seems to be of special importance in the highest regions of Asia, where it may be formed even in summer. Pl. 7 shows Minya Gongkar from the north, with its summit completely covered by a mantle of bright white ice. It sticks even on the vertical walls, where no ice could be formed of snow. Hoar ice produces rounded surfaces. By this and the cleanness it can be distinguished at long distances. In Pl. 7 the lower limit is easily traced between 5800 and 6000 metres; in Pl. 8 (M. Tai) it is at the same level however, without forming a level line.

Even when the sky in winter is clear, all around the highest peak of Minya Gongkar is capped with a white streamer. Sometimes it is made of snow drift, but frequently it must be fog which produces hoar-ice crystals.

The snow line, on account of bad weather, could not be determined accurately. On the west side of Minya Gongkar it seems to be between 5200 and 5400 metres.

Ablation and drainage

As a result of the writer's observation we can state that all the water of Minya Gongkar is drained to the east by the Tung-ho. The glacier water from the west side is collected by the Butshü river. It was estimated at Pawa at the beginning of September 1930 as yielding 40 cubic metres per second. About 80 per cent. of this amount seems to derive from ablation. A similar amount may be produced on the eastern side of Gongkar range. We thus come to a total of roughly 100 cubic metres per second. This figure is still very small as compared with the enormous amount of water carried by the Yangtse in times of flood.

The tropical form of snow melting called *nieve penitente* was observed in Pawa Valley at 5200 metres (October 30) and on Haitseshan on the north-east side of Mount Jara, 50 kilometres north-west of Tatsienlu, at 4400 metres (6 January 1931). (Pl. 15)

Extension of former glaciation and of fluvioglacial terraces

Let us first record some observations on terminal moraines and erratic blocks. The greatest difference between recent and old moraines was found

on the west side of Minya Gongkar. Indeed, the slope at Tshümi (Tsemi) is strewn with huge blocks of granite derived from the summit of Minya Gongkar. The last erratics were noted about half-way between Tshümi and Muka, at about 3400 metres. The pleistocene glacier thus had a length of about 18 kilometres as compared with the actual 10 kilometres, the glacial tongue reaching about 400 metres farther down.

In the Pawa valley the side glaciers just came together. There the old moraines pass into a vast fluvioglacial fan deposit which extends far down below Pawa in the Butshü (Tienwan) Valley (Sketch-map).

The old moraines of Yantsöko Glacier only extended 2–3 kilometres below the block-covered ice of the present time. There the fluvioglacial terrace commences about 40 metres above the glacial river, its surface dipping 8–9 degrees in the direction of the valley. Some 4 kilometres farther down, the terrace is at 50–60 metres, dipping 6–8 degrees towards east.

At the villages of Lamasze and Mosimien the same fluvioglacial terrace is widely extended and cultivated. Its general slope is 5 degrees to east. The rivers on both sides have cut out deep channels down to more than 100 metres below the table terrace. The thickness of the fluvioglacial deposit in places may exceed even 100 metres. Frequently large blocks of several cubic metres are enclosed in the coarse gravel. On the surface of the terrace some granite blocks of 10–20 cubic meters were observed, and one of even 100. It is difficult to explain their position. Possibly they fell down from the slopes before the side ravines were formed.

On Hailoko Glacier little, if any, signs of a larger extension of the former glaciation are left in the uppermost part (Pl. 12). Above the knee a left side moraine is preserved, which reaches 15 to 20 metres above the ice. The granite forming the knee is nicely polished up to about 20 metres (Pl. 2). In the lower part of the glacier the left side moraine is overgrown with jungle of fir trees, larches, and rhododendron.

Two crests may be distinguished here, an inner one 15–20 metres above the ice, and an outer, still older one at about 25 metres. Near the glacial gate this old moraine is 60–80 metres high, but seems to reach its end already 2–3 kilometres farther down stream. No connection was seen with the fluvioglacial terrace so well traced at Yantsöko Valley. It seems that the passage zone has been washed out by side streams. But 10 kilometres farther down, at Hailoko (Chinese mountain farms), the fluvioglacial deposits are well developed.

The gravel terrace corresponding to that of Mosimien is at about 70–80 metres above the river. Above it two more terraces were observed. They seem to be terraces of erosion, one at about 130 and one at about 300 metres above the river.

The continuation of the terrace of Mosimien (Mosimien stage of glaciation) is interrupted by a granite gorge, but is recognized again along the Tung-ho. There, in the region of Shabatse, low terraces of 35 and 45 metres above the river were noted, while the high terrace is at 60–70 metres. It is the latter that seems to correspond to the widest extension of pleistocene glaciation (Mosimien stage).

7. Minya Gongkar and Yantsöko Glacier from N.

8. Mount Tai, from 5000 m., showing hoar ice on the crest, looking E.

9. Ice horn and glacier of Red-

9. Ice horn and glacier of Red-

Solifluction

It is generally known that in cold regions where the temperature frequently changes around the freezing point, the slopes of talus are gradually slipping. Most beautiful examples of this kind were observed by the writer on the Nugsuak peninsula in Greenland. Even the bottoms of the side valleys there are slipping in the shape of a glacier, although there is no snow field above to collect ice. Solifluction also is known from the Alps, as for instance in the flysch region of the Segnas Pass.

Chinese Tibet in greatest part is made of slates and sandstones of the flysch type. The most characteristic solifluction in this region was observed on the north side of the Rutshe Pass, 20 kilometres north-north-west of Minya Gongkar, at elevations from 5000 metres down to 4200 metres (Pl. 9). More than 5 square kilometres are slowly moving downwards. The plates of slate, especially in the ravines, are frequently raised up (Pl. 9, black spots at right foreground). The cushion plants which cover the ground are torn by cracks which illustrate directly the amount of slipping. Frequently also the stone plates are found in a geometrical order.

Other places of widely extended solifluction are the north-west side of the Cheto Pass west of Tatsienlu at 4600–4000 metres, and Haitseshan Pass at 4500–4200 metres.

In the background of the Pawa valley at 3800 metres, and on the Yatsiaken Pass, at a similar elevation, huge fields of angular blocks were encountered. They have neither the shape of moraines nor of a mountain slide. Rain and fog at Yatsiaken made careful observation impossible. On the north-west side of this pass some small lakes dammed by ground moraine were noted down to about 3600 metres. As a rarity it contains some pebbles of striated Serpentine, a rock not yet known *in situ* in the whole region. Bad weather did not allow me to determine whether this moraine has slipped down by solifluction.

Usually the striæ of solifluction are easily distinguished from those of glaciers. They are more superficial and chiefly or exclusively found on softer and angular rock fragments like slates and sandstones, while those from glaciers, on account of the higher pressure below the ice, may be found on the hardest rocks which frequently are rounded and polished.

Von Lóczy of the Szechenyi Expedition has accepted a very large extension of former glaciation. It seems to the writer that he has confounded striation by solifluction with true glacial striation. In every case it is of greatest importance to give most careful attention to these pseudo-glacial deposits in regions of frozen ground.

Morphological features

The morphological observations are conformous with the determination of the end moraines. Rock polishing so general in the Alps, in Scandinavia, and in North America is rather exceptional on Minya Gongkar. None of the valleys shows the signs of glacial erosion. All the main features are those of water erosion. The old side moraines in the Pawa valley and in the upper Butshü valley just reached the valley bottoms at 3800 and 4000 metres without extending farther down (Sketch-map and Pll. 1, 4, 5, 11, 12). Already the

distant view of the Butshü valley with its sharp crests is characteristic of a non-glaciated valley (Pl. 12).

In vain also the writer sought striated pebbles in the Tatsienlu valley. Neither the Lamoshé nor the Tatsienlu Glacier seem to have ever reached the bottom of the main longitudinal valley.

The above observations show that the former glaciers were more widely extended than they are now, but not to compare with the pleistocene glaciation of the Alps. The former glacier tongues reached 200 to 500 metres farther down at the most. Taking the length of the present stage as 1, the former glaciers reached 1·1 to 1·6 (Gomba 1·6, Yantsöko 1·2–1·1, Reddomain 1·3). In the Alps, where the present glaciation is of the same type, the proportion is from 1 : 12 to 1 : 30, the early glaciation thus twenty times stronger.

The great feature of the pleistocene glaciation is the fluvioglacial deposit. The terrace gravels washed off from the former moraines have a more gentle slope than the actual valleys. The Yantsöko and Hailoko glacial rivers have cut themselves into the gravel terrace 30–40 metres deep in the upper part, 50–60 in the middle, and 70–110 metres in the lower part (Mosimien). The deposition of the vast fluvioglacial material that fills the valleys must have occurred at a time of lesser fall of the rivers. The cause of the accentuation of erosion in recent time must be the general uplift of the Tibetan mountain region. This result already was derived from a study of the platform of Chinese Tibet which must have been formed at lower levels. It was a semi-mature landscape lifted recently into higher levels. The vegetation also points in the same direction. The extreme abundance of semitropical plants mixed with alpine types is explained by the lack of glacial destruction and by this quaternary uplift. Thus the subtropical forms became gradually adapted to the cooler climate, while the nival forms had to migrate downwards and to join hands with their companions from below. All such reflections result in the conclusion that the general cold climate of the pleistocene ice age at the eastern Tibetan front ranges was nearly counterbalanced by its formerly lower position. This is the writer's explanation for the relatively small extent of past glaciation.

DISCUSSION

Before the paper the PRESIDENT (Major-General Sir PERCY COX) said: The paper this afternoon is on the "Glaciation and Solifluction of Minya Gongkar." Professor Arnold Heim, who is reading the paper, has travelled over a great part of the world and was for some years Professor of Geology in the University of Canton. He is the distinguished son of a distinguished father, who also was a great geologist.

As those of you who have attended recent meetings of the Society know, a great deal of attention has been paid to the movement and behaviour of glaciers, and Professor Heim proposes to address us on this subject. The word "solifluction" was new to me when I heard it recently. I could not find it in the dictionary, and when I asked a friend the meaning of it he said that he was not sure whether the "soli" element in the word referred to melting from the heat of the sun or to movement of the soil. Professor Heim tells me that, so far as he is concerned, it is a word introduced by Gunnar Andersson: and that it relates to the fluctua-

10. Lower Hailoko Glacier, looking down stream

11. Upper Hailoko Glacier and Minya Gongkar from S.E.

12. Upper Butshü Valley shaped by water erosion, looking N.E.

13. Banded ice near end of Great Gomba Glacier

14. Chiburongi (6000 m.) and Djaze Glacier

15. Nieve penitente, Haitseshan (4400 m.)

tion or movement of the soil, and not to melting by the sun. With this brief digression I will ask Professor Heim to read his paper.

Professor Heim then read the paper printed above, and a discussion followed.

The PRESIDENT: Before we go further I should like to ask you to join me in congratulating Professor Heim on the extraordinary perfection and fluency of his English. And now I call upon Professor Boswell, Professor of Geology at the Imperial College, to add a word or two.

Professor P. G. H. BOSWELL: I thank you, Mr. President, for the privilege of being able to join in the tribute to my friend, Professor Heim. As the hour is getting late I will be brief and refer only to two of the geological questions which he raised.

First, his main thesis is that on the evidence of the morphology, the absence of extensive ice scratching, and the mixture of the plant life, this area has, unlike certain other mountain ranges with which we are familiar, risen in comparatively late geological times. Professor Heim is well familiar, of course, with the fact that the extent of glaciation depends not only upon elevation but on the amount of alimentation, and thus on the proximity to ocean waters and the direction of moisture-bearing winds. Although I feel that he has established his thesis on several grounds, probably he will be able to tell me that he has definitely ruled out all possibility that past glaciation here was the result of the non-arrival of moisture-bearing winds.

I feel that the remarks on solifluction—the second point I wish to make—are going to be of very great value to us when we are able to read them in detail. Studies of solifluction phenomena at the present time are far too few. We happen in this country, and of course we share that condition with certain other European countries, to be just on the position of the oscillating ice margins of the great Ice Age, with the result that here where we are standing at the moment we can imagine glaciers reaching perhaps as far as Finchley to the north, and solifluction phenomena, soil creep, and so on, going on in the area southwards to the English Channel. Those deposits have puzzled geologists for many years. They have been attributed to frost and soil movement, but with some caution, and it is not surprising that geologists were afraid of getting cold feet. If we can have present-day evidence of solifluction described from such regions as those that Professor Heim has visited, then such evidence will be of great use to us in the interpretation of solifluction phenomena during the later stages of our own Ice Age here.

There are many other interesting points that Professor Heim has touched upon, but I feel that I must finish with the expression of great pleasure and satisfaction at the success which Professor Heim has achieved in his expedition and in his lecture.

Professor HEIM: The President has asked me to reply to Professor Boswell, and, in doing so, I would point out that when the whole mountain range was lower than it is at present, the alimentation of the moisture was also less, so that is only a further point in my favour.

Professor BOSWELL: Let us not assume that the range is higher now than it was.

Professor HEIM: Yes; but then I do not know whether there was any evidence that the moisture previously was less, so we need not even in that case accept that the mountain was less high because it was so little glaciated.

Mr. PATERSON: I have listened with great interest to Professor Heim's lecture, in view of the work in which I have been engaged during the last three years. I was with Mr. Wordie on his expedition to Baffin Land in 1934, and there paid particular attention to this very phenomenon of solifluction which Professor Heim

has called to our notice. During the summer of 1935 I was busy in the North West Himalaya studying these same phenomena and the glaciations there, so that Professor Heim's observations, though they be in a region fairly far removed from those where I have been working, certainly are of importance to my particular study. I found there many parallels which one might draw.

In the first instance, I am interested to hear and to see Professor Heim's evidence for the action of ice and how much one can attribute to that factor, because I found in the Himalaya that the major part of the erosion is due to the action of water proceeding from the glacier and not to erosion by the glacier itself. Secondly, in Lower Pleistocene times the Sind glacier, now measuring less than two miles in length, was then 60 miles long, a comparison of the order encountered in the Alps. But in the Middle Pleistocene the Pir Panjal or Outer Himalaya was elevated almost 4000 feet and subsequent glaciations nearer the core of the main range were much smaller, which may be due in part to the blanketing effect of the newly risen mountain range, where also corresponding later glaciations were much more extensive. That may help to solve the question which Professor Boswell has raised.

As a third point, the matter of solifluction is deserving of attention because I find in the regions north of Kashmir large areas of *Felsenmeer* similar to those described by Arctic travellers. In Baffin Land these enormous areas of stones extend for as many as 30 square miles, reaching finally to a base angle of slope as small as 5°. Even then stones many tons in weight can move. In the Sind Valley of Kashmir I have seen deposits up to 200 feet thick composed entirely of solifluction material. Solifluction it seems, then, is a factor in geographical development which cannot be ignored and therefore excellent observations such as those of Professor Heim assuredly are of value to a study of that factor.

Professor BARBOUR: In expressing my thanks to Professor Heim I need only add that his picture of the glacial history appears to accord perfectly with recently developed ideas regarding the topographic changes connected with the evolution of the Yangtze, more particularly with its diversion from a previous southerly course during the Pleistocene Period. May I add to the appreciation already expressed by others my own gratitude for a lecture of such interest so well presented.

The PRESIDENT: We should like to have heard Professor Mason, but he has had to leave to catch a train. He has however left a few notes which I will ask Mr. Hinks to read.

The SECRETARY then read the following from Professor MASON: I should like to say how much I have enjoyed Professor Heim's extraordinarily instructive paper. The detailed exploration and survey of this region must have an important bearing on the question of the extension of the Himalaya east of the Tsangpo–Brahmaputra gorge.

In this connection I think there are certain pointers of great interest in Professor Heim's paper. He has, I understand, concluded that the mature landscape of this region of late Tertiary times has been uplifted in Pleistocene times, a conclusion derived from the vast fluvioglacial deposits of an earlier epoch, by the subsequent rejuvenation of streams, and by certain vegetational evidence.

Far away from Minya Gongkar Dr. de Terra has come to a precisely similar conclusion from a study of the terraces and deposits in the region of the Pangong lake and eastern Karakoram. In that region Dr. de Terra has suggested a post-mature landscape in late Tertiary times, with four subsequent periods of uplift, separated by three pleistocene ice advances and followed by dissection.

The same general morphological features at such widely separated intervals

of course proves nothing; but, taken in conjunction with other evidence which is gradually accumulating, it does seem more and more probable that these Tibeto–Chinese ranges, with their strongly marked north–south trends, bear the same relation to the supposed flexure of the eastern Himalaya as the Karakoram–Hindu Kush ranges do to the western Himalaya.

In the north-west we have the resistant horst of ancient India projecting northwards and influencing the trends of all the mountains north of it as far as the Pamirs. In the east there is the resistant block of the ancient Shillong plateau projecting north-eastwards, similarly influencing the trend of the mountains north-east of it. In the north-west the Himalaya have been moulded, with a sharp flexure, as Wadia has shown, round the horst. Beyond the Himalaya the flexure of the Karakoram–Hindu Kush is less acute and, as de Terra has shown, the Karakoram–Tibet region has been raised in very recent times. Wadia, Misch, and de Terra have all shown in different parts of this northern region that even the most recent deposits have been tilted, a fact that shows that these mountains are not yet at rest.

In the east our scanty evidence all points the same way. The ancient Shillong plateau is so stable that the Tertiary deposits lie horizontal and undisturbed along its southern flank. But to the north-east and east there is unrest. The younger outer ranges seem to have been moulded with an even greater flexure round this block than in the north-west; their trend changes sharply from east-north-east in the Abor hills to north–south, and then to north-east–south-west round the head of the Assam valley. Behind them and farther to the east we see an apparently gentler flexure of the Tibeto–Chinese ranges which, in the region examined by Professor Heim, show characteristics identical with those of the Karakoram.

I very much hope that Professor Heim will be able to continue his studies in this field.

The PRESIDENT: It only remains for me to thank Professor Heim most warmly for his interesting and valuable paper. I am sure the experience of many here will lead them to agree with his when he says that on these arduous journeys the tendency is to forget the difficult and unpleasant parts, and to remember only the bright patches. Indeed while he was displaying those beautiful pictures the thought was in my mind what an infinity of toil and perseverance it must have cost him to reach his objective. We must compliment him too on the very clever imitations he gave of the cries made by the Tibetans as they go over the higher passes.

I ask you now to join me once again in thanking Professor Heim for his most interesting lecture, and at the same time express the hope that fortune will enable him to continue his studies of these glacial problems.

Dr. KENNETH SANDFORD sent the following contribution to the discussion: Professor Heim's paper reintroduces from another angle the question of the relative efficacy of rivers and glaciers as valley-eroding agents in mountains. Professor Garwood sifted the evidence and revived this long-standing controversy, so far as it concerned the Alps, in his Presidential Address to the Geological Society in 1931: the tendency in the Alps and Himalaya seems to be toward crediting rivers during glacial minima with profound vertical erosion, and glaciers at their maxima with smoothing and steepening of the valley sides.

In the valleys around Minya Gongkar down-cutting seems to have preceded the deposition of the great fluvioglacial gravels, for Professor Heim quotes from the vicinity of Lamasze and Mosimien gravels possibly more than 100 metres thick and now eroded by rivers to that depth. But there are two terraces of erosion, at 300 and 130 metres above the river in the Hailoko district: there

are therefore at least three periods of river erosion, and now a fourth, and one, at least, of great fluvioglacial accumulation. These recall in some measure de Terra's results, and both authors attribute one or more periods of river erosion to general uplift.

Professor Heim proves the striking contrast between the present and former lengths of glaciers in the Alps, ratio 1 : 12 to 1 : 30, and in this part of Tibet, ratio 1 : 1·1 to 1 : 1·6; he attributes the small ratio of Tibet to lower elevation during the Ice Age than at the present day. While welcoming the further demonstrations of Pleistocene elevation and valley deepening in Tibet and the Himalaya, which may still be in progress, I would like to ask Professor Heim whether the geographical position of Minya Gongkar with relation to the distribution of monsoon rains would not fully account for the small ratio of Pleistocene to present glaciation. In this region there seems to have been no glacial overloading at any time, and it is unlikely therefore that the progress of elevation has been hindered by any extrinsic factor.

Why, then, has elevation halted at intervals? Have there in fact been pauses? If we assume, as it seems we must, that the causes of checks in elevation in this region are geophysical, we must not be too ready to assume that glacial overloading has played a part in punctuating uplift of other parts of the mountain arcs and plateaux.

To conclude therefore even if some of us may be unwilling to accept the ratio of glacier length as evidence of recent uplift, there is abundant evidence of general elevation in the trenching of the valleys. The periods of elevation, pause, or even reversal of movement, here and elsewhere, may be the cause and not the effect of variation of glacial load. Our thanks are due to Professor Heim for this further demonstration of the danger of dogmatizing about Quaternary climate and ice ages from as yet insufficient meteorological and geological data.

THE EBRO DELTA

E. H. G. DOBBY

WHETHER you catch a glimpse of the Ebro delta through the olives and algarrobas which line the railway from Ampollo or whether you take a wider view from a vantage point at the top of Amposta church, the delta presents distinctive features. It is so flat that one hardly believes such flatness could be natural. Its rough rhombus shape has edges of more than 18 km. to which the river forms a diagonal of some 28 km. Immediately before entering its delta the river follows an almost north-south course until its waters, striking the low conglomerate outcrop at Amposta, are deviated to a due west–east course. From Amposta the river is entirely deltaic and its course to the sea is remarkably straight. This is because the profile of the Ebro is steeper than that of any other deltaic river in Europe. The digital forms, so common to deltas, are completely absent. Curious tombola formations of marine sands stretch away to the north-west and south-west from the mouth. The delta is asymmetric; the northern and southern outlines resemble one another, but everything on the southern side is much larger. The northern tombola is some 6 km. long; the southern is nearly 15 km. long, and forms the natural harbour, Puerto de los Alfaques. The presence of these tombolas serves to indicate two forces at work in constructing this delta. The river itself has deposited landward materials; more exceptionally, gentle onshore currents of the Mediterranean have accumulated the sands on the seaward margins. The form of the delta is by no means constant. There has been an addition of some 50 metres all round during this century alone. On the left delta human activity increases the rate of change by gradually removing the brackish waters ponded behind parts of the tombola. At the mouth the change is greater than elsewhere because the consumption of water from the Ebro slows up the stream and increases the rate of deposition. Consequently the Faro de Buda, which was originally built on the northern side of the mouth, is now on the southern side and surrounded by a couple of new islands. The actual mouth is extremely shallow and has hardly more than 2 metres depth. A strong on-shore wind is capable of holding up the outflow of water. Discoloured fluvial waters can be seen splaying far out to sea, spreading out northwards, for instance, almost to the latitude of Atmella. As if to emphasize the flatness of the delta, strings of poplars cut the view in straight and artificial lines. These poplars are grown on both banks of the main canals. Along the Ebro itself and most of the minor canals dense masses of reeds rise 4 or 5 metres above the surface.

Although nothing in the nature of a hill disturbs the continuity, this surface is not quite so flat as the first impression suggests. No map could show such relief as the levées or the foot rise that surrounds every field and makes each riceplot like a shallow, rectangular pan. The subtle relief of the delta is best brought out by considering the areas inundated during times of flood. The first area to be flooded is a fan-shaped zone from north of Amposta, stretching to a width of some 5 km. at the Fondeadero del Fangal. The second area to be flooded is generally a similar fan-shape symmetrical to the other in the

southern delta. In times of maximum flood the whole delta may disappear under water, except for the immediate river banks near La Cava, which are levées some 2 metres above the delta. These levées have sometimes disappeared under water as well. The greater height of the river banks is due to regular re-flooding by the heavily laden waters of the Ebro. Many of the older houses now have doorways so low that it is necessary to stoop when entering. These doors were originally built to a normal height, but deposits by flood waters have reduced their effective heights. It is estimated that there has been an increase of some 50 cm. along the banks in the last thirty years. Floods occur with fair regularity every year, March being the month of maximum danger.

The soil is a fine alluvium in varying stages of drying out. The colour is a dull yellow and its clayey nature greatly helps to conserve the irrigation waters. When the irrigation water is led off the ground begins to dry out and, like most clay soils under intense summer heat, splits into a net of deep fissures. At no time however during even the driest part of the year does water stand far below the surface, and this heavy soil needs three horses to pull effectively a single-bladed plough. The sub-surface is of two main types: firstly, an acidic sub-soil of a peaty nature from buried vegetation of old marshes; secondly, a sandy silicious sub-soil, possibly of marine origin, in which salt tends to accumulate at about 25 cm. depth. A soil section is very difficult to find on the delta. The rapid erosion of the river just opposite La Gracia gives a fine example of levée section: at the top, half a metre of loamy alluvium; beneath this, another half-metre of peaty material, black with much woody vegetation not very advanced in decomposition. Below this again, another half-metre of heavy clay whose deeply fissured black structure shows that it had been well dried out before the succeeding clays were laid upon it. Salt crystals can be seen very prominently between the upper and the peaty layers. The subterranean waters present a curious phenomenon. An artesian basin covers a large part of the delta. Great jets of fresh drinking water shoot up if the bottom of the Ebro is pierced. When boring for the foundations of Amposta bridge artesian water was met at a depth of 22 metres and rose nearly a metre above the surface of the river. Two or 3 km. above Amposta, natural springs of fresh water can be seen lying in clear mantles upon the thick river waters. Yet none of the wells on the delta proper are artesian wells; the delta wells are wells of accumulation and retain the old endless chain of jars to lift the waters. The natural vegetation is now in retreat under the continued advance of cultivated crops. Wild vegetation over any area is now found only about 5 km. east of La Cava. On the outermost and least salubrious lands high reeds and coarse grasses nourish a few cows which are always tethered, and some wandering herds of goats. Parts of this area once raised *toros* for the bull-ring as well. Over the whole delta are vast numbers of insects, some entirely aquatic and others with only aquatic larvae. Upon these insects and the aquatic flora live vast numbers of frogs and toads, and upon these in turn prey great flocks of aquatic birds of the duck type. These birds have their habitat in the large ponds and swamps of Creu, Illot, Estella, and Tancado. They sometimes move by the thousand into the rice fields, and on these occasions enormous parties are organized to hunt them. They

come into the rice fields especially in August. Great numbers of small brown water-rats infest the water conduits.

The features which man has imposed upon the landscape of the delta are very prominent. In them lies the economic value of the delta. Man has not interfered with the river course itself to any great extent because, as in all deltaic rivers, slight obstructions in the stream are apt to cause unexpected results. On one occasion it was feared that the Ebro, eating into its right bank, was approaching within dangerous distance of the Right Canal. For this reason a small breakwater was built above the danger spot, projecting some 5 metres into the river. Water was deviated from the levée near the canal, but at the same time took on a fresh course which inundated a new area on the north delta and obliterated much land which had previously been productive. Since water lies, as we have seen, so close to the surface it may seem strange that a complicated grid of irrigation canals has been constructed as well. Two large canals take water from the river at Cherta, and parallel the Ebro, one on each bank. In addition, a disused navigation canal runs due south from Amposta and provides further irrigation waters. Poplars planted along the banks consolidate the loose earth of which the banks are made. A wide fan of side canals carries water from the main channels. This system has been elaborated because water in itself is not sufficient for cultivation purposes, especially for the cultivation of rice, which is the only one economically justified on the delta. Water needs to be applied at a particular time and, more important still, needs to be drained off at some other time. The network of side canals and distributories has been carefully gauged so that they prevent floods to some extent and occasionally act as drainage ditches. Any one field can be flooded or drained without interfering with arrangements for any other adjacent patch of land.

The side canals are of two types. First, the *acequias*, which lead the water from the main canals to the fields; these *acequias* are made of brick and stand up above the surface of the delta in a rectangular network. Second, the waters are carried away from the fields by *desagues*, which are quite distinct from the *acequias*, being nothing more nor less than graded ditches, unkempt and often thick with wild vegetation. The levées have no controlled irrigation from the canals. They generally raise water directly from the river itself. On these levées, both sides of the river, are broad bands of vegetable gardens, whose regular green colour and constant rotation of vegetables contrast with any other part of the delta.

The total area of the delta is about 24,000 hectares, of which 14,000 are cultivated under rice and something more than 2000 devoted to horticulture, leaving about 8000 hectares completely unproductive. Much of this unproductive marshy land could be brought into cultivation were more drainage carried out, but this is delayed because many of the lagoons are national reserves for fish. The delta has an average height of hardly 1 metre above average sea-level, and since a given particle of water must often travel 12 km. after it leaves the main canal, its velocity is necessarily small. Deposition of sediment and slime makes necessary the expenditure of much effort and money for the cleaning of all channels.

The main canal on the right bank was begun in 1862, that on the left in

1912. The Right Canal was not originally built for irrigation. Following the Napoleonic wars, a French general had the idea of increasing the usefulness of the Ebro by making a navigation canal, and this was constructed between Amposta and San Carlos. Its value was not great. The waters for it were led directly from the Ebro and, when they passed through the locks, left great deposits of sediment which were a constant trouble during the time that the canal was in use for navigation. So rapidly did sediment accumulate that running water was sought to quicken the speed of water in the navigation canal. Hence the construction of a dam at Cherta to lead off the Right Canal for cleaning the navigation canal. Later, when the tonnage of ships increased and made navigation of the Ebro impossible, the canal fell into disuse. The Cherta canal was finally continued right out into the delta for irrigating. Other signs of French influence are seen along the navigation canal. There are many French surnames and a so-called "French circle" in Amposta. Furthermore, the close network of lanes and paths southeast of Amposta is evidence of earlier use of the delta in that part.

As in all irrigation undertakings, the question of salt occupies much attention. The amount of land which has become saline through irrigation is not very great at the moment and that waits only for a new period of economic prosperity to give sufficient money to enable proper remedies to be undertaken. The salt tends to appear at the surface mostly in the areas of vegetable gardens and was even greater in the days when well-water was the main source of irrigation. The water is led from wells by a shallow ditch and filters into the soil from them. It is later brought to the surface by capillarity and this, in combination with the high temperatures, rapidly leads to the appearance of the dangerous white crystals at the surface. The greatest amount of land abandoned because it has become saline is now found near Jesus and Maria. Such lands can be made wholesome again by being planted with rice, not because rice tolerates the presence of salt in the soil, but because the special form of applying the waters carries away the salt. The water is led on at a high level, passes through the field to a lower level and given two years of very deep ploughing the soil can finally be brought to fresh condition and replanted again with vegetables. Canal water coming directly from the river with a high alluvium content has a low percentage of salty materials and lessens the tendency for salt to appear at the surface. There is more vegetable cultivation on the left bank than on the right.

Delta prosperity is a comparatively recent thing. The opening of the Left Canal in 1914 coincided with the beginning of the Great War and its blockades: this brought enormous profits overnight. Previously a few poor fishermen settled in mean houses along the less dangerous inlets, carrying fish laboriously upstream to Tortosa and Amposta, or hunted the wild birds of the marshes. Sixty years ago on the La Cava side only some twenty houses existed, the rest being *barracas*, or reed huts, to the number of three hundred. At the present time it is almost impossible to determine exactly the population of the delta, because it is divided up into municipalities whose statistics overlap other regions, so that without the labour of making a special delta census, a population analysis is impossible. However, considering the figures given by local authorities, doctors, and irrigation societies, the figure of 10,000 seems reason-

ably correct for the present population. This over an area of 520 square km. gives roughly 20 persons per square km., or 1 person to 3 acres. Before the canals there had been practically no cultivation and the delta served only to raise cattle, donkeys, and reeds. The sole crop of the region was then *salsola*. This was gathered in June and July, burnt, and the ashes used for making soap. Under these conditions the life of the inhabitants was extremely simple and precarious. Their food was almost exclusively vegetable, based on maize bread and beans. By far the greater part of the delta was then covered with immense areas of salt marsh. From these salt was recovered by the simple process of letting the sun evaporate the water. This salt industry developed considerably, until the construction of canals caused fatal inflows of fresh water into the salt pans. Most of these old *salinas* are now given over to rice. There are still signs of *salinas* round the middle of the delta and near Amposta, which owed its early importance exclusively to the salt trade. The only *salinas* to-day are worked on very modern lines with jetty and miniature railway, and stand on the inner side of that lobe of the delta, south-east of San Carlos. It is impossible to reach these *salinas* by any means other than boat, and all connection with them is by water from San Carlos. Only six or seven houses and a few official buildings there give permanent evidence of human beings by the modern salt pans.

Buildings on the delta are only just losing the appearance of temporary dwellings. Formerly people lived on the higher quaternary conglomerate of the main land, and moved out to their working fields each day by cart. As this distance of cultivation became greater and agriculture was pushed farther into the delta, need arose for the workers to stay a season near their fields. There are still many of the early buildings, in an inverted V-shape, built entirely of rice straw or reeds and plastered with clay at the ends. These *barracas* are of wicker, with a single floor which is occasionally divided into two by a low wicker screen that separates the animals from the living quarters of the human beings. With increasing prosperity whole families went to live permanently in these huts until replacing them with newer brick houses. These are usually single-floored, with a great verandah outside which forms the open-air living-room for eight or ten months of the year. They are often built on a raised platform about a metre above the surface. Inside they rarely have more than two rooms, and the upper chamber is generally a granary or storeroom owing to the risk of floods on the ground floor. The stable, if any, is built on to the body of the house in the manner of a lean-to. The congestion of people is often very great; the whole family may sleep in one room with the animals only separated from them by a wicker screen. Entry to the stable is often through the family bedroom. These unhygienic arrangements, combined with the millions of mosquitoes which thrive on the stagnant waters, caused great plagues of malaria in the early years of human occupation of the delta. As many as four hundred people died in each of the three summer months of the Great War years. To-day, owing to intense activity on the part of anti-malaria clinics, the number of deaths from malaria is negligible, and the number of suspected cases rarely exceeds one hundred per annum. Construction of houses has been so rapid that a map five years old gives little idea of house density. This is customary when what was a poor country-

side suddenly becomes prosperous. The foundations of modern houses are not merely raised-earth platforms; a wall of open stone-work loosely laid together is first constructed and then filled inside with clay. The ordinary brick wall is then built upon this foundation. The idea of the open foundation is to give flood waters ease of exit. Roofs are, to all appearances, flat, and a pipe carries from them any rain water to be stored in a cement container for domestic use. Outside each house is the oven, a cylindrical structure of baked clay, hemispherical at the top, standing some 6 feet high, with a whitewashed exterior which only reveals its use by smoky discoloration round the top. The whole delta depends for its domestic water supply upon stored rain water, since both canal water and ground water are quite unsuitable for drinking purposes. Every house is whitewashed outside, as a protection from the heat, and whitewash is often applied twelve or fifteen times a year.

The habitations are distributed in three ways: marginally, centrally, and dispersedly. The drier landward margins, giving possibility of work in two different geographical regions and affording protection from floods, attracted settlements from the beginning. Houses on this landward margin stand always on the quaternary conglomerate formation and seem to choose the sharp, cliff-like drop from this conglomerate as a favourite site. Yet the main activities of those who inhabit these dwellings are in the delta. A string of marginal wells brings typical vegetable cultivation right up to the line of geological change. The most important string of dwellings in this class runs due south from Amposta, strongly influenced by the main highway which follows that geological margin. The settlements there have the advantage of a string of wells more reliable than those on the northern or Aldea margin. Aldea is a small group of such dwellings which have assumed the importance of a village owing to the railway which here has its nearest station to the delta. As a consequence, many de-husking factories and rice warehouses have been built in Aldea. Dwellings on the actual delta retain a dispersed character; that is to say, no house is built with a party wall common to the house next door. Within a radius of some 5 km. from Amposta, on the southern delta, is a patch of such dispersed houses linked up by a network of cart tracks and lanes. Elsewhere, real disperson of dwellings does not exist. Centrally, the habitations concentrate at La Cava and at San Jaime. La Cava is best defined as a nucleus of houses between the Left Canal and the river covering a distance of about 5 km. San Jaime is a similar but much smaller group across the river. La Cava contains all its houses within less than 5 square km., yet that includes practically every settlement on the north side of the delta. Each house of this group preserves the self-sufficing type of dispersed houses, each standing surrounded by its own vegetable garden. The general haphazard and unplanned arrangement bespeaks the temporary uses to which these houses were put originally, and also indicates the recent feverish prosperity which has perpetuated them. Permanent brick houses and the older dwellings of rice straw and wicker stand side by side. The group tends to nucleate into three parts but is not sufficiently marked to make it anything but one grouping. Religious place-names are extremely common to parts of the group (Jesus, Maria, etc.), and bear witness to the efforts of Jesuits who tried to educate and help those early settlers whose condition of living was so bad. It is hardly

likely that this settlement will grow into a town because there is nothing to attract anybody but cultivators and farm labourers, whose market and business attention remains in Tortosa.

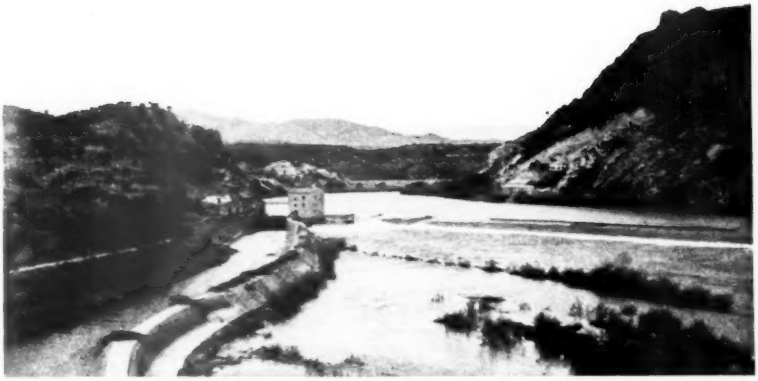
La Cava stands upon what may be called a levée of the Ebro. When floods occur, La Cava remains isolated as an island, except on the most rare occasions. It stands well back from the actual river bank because long inlets have been constructed to permit the vegetable gardens to be irrigated directly from the river and thereby save the usual irrigation charges. The whole settlement is within *huerta* cultivation. In that way the population gets some protection from the mosquitoes which infest the flooded rice fields. The domestic drainage problem is naturally very difficult, and for that reason the hygiene of the group is very primitive. It is significant of the problem that normally the dead are buried in a grave with a water pool at the bottom. Flood dangers to La Cava occur quite frequently without being regular, and at such times every man in the settlement turns out to help build an earth wall round it. A cordon of about a yard high has been placed round the whole settlement within six hours. This cordon serves to protect the houses and *huertas*. Its importance is greatest for the *huertas* since the carefully graded systems of channels that are hardly more than breaks in the surface are completely obliterated by a few hours of flood. When the danger of flood is removed this temporary earth wall is undone and its materials worked into the fields again. Building materials have to be brought from a distance; stone comes at least 10 km. from the conglomerates, and bricks often come 25 km. from factories near Tortosa. Woodwork is reduced to a minimum because of its cost and its inability to withstand the variations of humidity. The interests of the settlement are not quite the same throughout. La Cava, the extreme eastern section, has its prime interest in rice since it is the last suitable habitable site for the eastern sector of the rice-growing area. For the western section, in Jesus and Maria, vegetable gardening is the first interest, and the cultivators there grow 80 per cent. of the wheat consumed by the settlement, so that in this part great stacks of wheat straw may frequently be seen. This wheat is sown in autumn and is out of the way before the heavy labours of rice-growing are called for. The whole settlement is linked to Tortosa politically and has 40 per cent. of that municipality's population.

This grouping will be no transitory feature of the delta landscape. Its permanence is assured by the railway built out to La Cava about six years ago. This is an example of a railway built towards the people and not of a settlement created by the railway. Maps of more than six years ago, when there was no railway, show a population distribution not materially different from that at present. Early communication from La Cava was by steamer to Tortosa; produce and fertilisers went by shallow sailing boats. Both of these methods were very slow and unreliable because in the very season when rice had to be transported the river was at its lowest ebb. The railway is single-tracked and runs roughly on the embankment of the Left Canal. This railway links the settlement to its parent town, Tortosa, some 30 km. away. On the opposite side of the river to Amposta is one of this railway's most important stations; to it comes much rice for treatment in the mills of Amposta. The high road San Carlos–Amposta–Aldea has much traffic in rice which is loaded

high on mule carts travelling between the mills, Amposta station, and the main railway at Aldea. South of the river an intricate network of tracks links the southern delta to Amposta, which has taken on a double linear development. Firstly, a strongly marked extension along the road to San Carlos; secondly, a smaller extension along the southern Ebro bank, an extension significant of the daily migrations from Amposta into the rice fields. On this southern half of the delta appear far fewer inlets for direct irrigation from the river and no phenomenon of human conglomeration like that of La Cava. A slightly increased density of habitations shows opposite La Cava at San Jaime; its principal contact is *via* a ferry to the La Cava railway. Strictly speaking, the Ebro acts as a clear division of the delta geographically since the two parts so formed contrast in historical development, in population, in distribution of the houses, and in economic outlook. The importance of the river as a line of separation is brought out by the fact that there is only one ferry between Amposta and the sea. The southern half has no railway, its old lanes sink into the soft alluvium, and this half has not even the economic advantage of a railway line running along its landward edge.

Roads on the whole delta are appallingly bad and are nothing more than deeply rutted cart tracks, mere marshy ways during the rice-flooding period and entirely impassable after a severe rain storm. Nothing heavier than the light local carts makes journeys upon them. The flatness and narrow metalled tracks along the main canal banks have caused bicycles to be the popular means of personal transport, a feature quite exceptional in Spain. Financial interest in the railway makes it highly probable that the bad system of roads will continue, since motor transport on the delta would remove all need for the railway. Motor transport would be very efficient for the intense seasonal requirements. The main Barcelona–Valencia highroad skirts the inner fringe of the delta on the quaternary conglomerate, crossing the Ebro by a bridge at Amposta which did not exist until 1919. A lead down to an old raft ferry is still visible below the bridge. At the time of that ferry Amposta was aligned to the resulting ways, and its high street led down to the ferry. Consequently, the main road traffic has now tediously to thread old narrow by-streets of the village, and as a result the high street is no longer the artery of the village.

The rhythm of any landscape is a function in the first place of the climatic sequence. In the case of the Ebro, no meteorological station lies within the delta. The nearest is at Aldea, but, although its elevation does not differ markedly from that of the delta, it is definitely off the delta. However, no great change of altitude occurs within some 8 km. of the point, and so this Aldea information may be taken as an approximate expression of the delta's climate. The chief climatic factors here are high temperatures and long sunshine periods. Very rarely do mists arise in the way they do on North European maritime flats. Throughout the year cloudiness is very low so that even in winter men wear broad-brimmed hats to protect them from intense sunlight. The winters are exceptionally mild; little domestic arrangement exists for house-warming—even the cooking ovens are built outside the houses; so mild are the winters that in certain places a second crop of wheat is taken out of the ground in May. Summers are intensely hot and so reliable in this



Cherta, where the canal serving the right of the delta takes off from the River Ebro

The low ridges which give the rice fields a pan-form. Stubble stands from August till the spring

A typical Delta plough and ploughman

On the right an old rice-straw "barraca": on the left a raised house of brick

A lightly built seasonal shelter for men and beasts

The "huerta" or vegetable belt

respect that rice, a most exacting plant for summer temperatures, has become the principal crop. The Ebro delta does not lack rain. It is independent of rain. To quote the average rainfall means little in this area where evaporation remains high throughout the year and where a high water table and constant irrigation add further disturbing elements to the value of rain. Throughout the year, north and north-west winds are strongest and most persistent. Calms form an important feature of the air condition, and the monthly average of calms varies little from half the total time. During winter the famous "wind from Aragon" blows with surprising intensity from the Ebro gorge, but out on the delta does not reach those high velocities associated with stations higher up near Tortosa. The Puertos de Beceite, a high land mass which towers above San Carlos, often chills local winds exceptionally and brings considerable frost risk to the southern part of the delta. Land and sea breezes are typical of the summer months and can be noted on about a quarter of the days of each month throughout the year. They blow from the south-west in the morning and from the north-east at night. They have little force and are normally of little height since smoke drifts often reveal contrasts between this lower wind and that 100 metres or so above. The position of the delta, low and thrust well out to sea, inclines it to uniformity of temperatures. This insularity is disturbed only by winds from the mainland. The monthly extremes are the only ones which ever descend below zero, and then only do so for two or three months of the year. The average monthly minimum only descends below 10° C. from November to March. These facts suggest the long periods of temperature suitable for growing plants. As far as the maximums are concerned, they regularly reach 40° C. for weeks on end during the summer. From the point of view of growing rice it is important to note that there is much danger of cold snaps just after the planting of young rice, and one of the features of the imposed landscape is the commonness of reed screens to protect the seed beds. In March and April ground frost becomes dangerous to the seeds and is caused partly by down-settling of air from adjacent heights and partly by great night radiation under the clear skies. This danger is limited to the early hours of the morning, and experiments have shown that the low temperatures are limited to the immediate surface. Repeatedly the ground will have a temperature of about zero, whereas 3 feet above the air will be at 6° C. It is this danger of late ground frosts which has brought to nothing attempts to grow cotton.

The special character of humidity at La Cava and the delta proper is the wide diurnal variation which may bring a change from 0 per cent. humidity during the middle hours of the day to 100 per cent. humidity during the night. Graphs of humidity throughout the year show an even 70 per cent. average for each month, while the mean monthly maximum never descends below 90 per cent. Thus, the diurnal humidity varies more than the monthly variations during the year. The great area devoted entirely to rice cultivation, and the long periods of flooding involved, are the artificial causes of this humidity. Even in midwinter mists hardly average one day per month, while in summer there is no mist at all. Dew, conditioned by humidity and rapid loss of heat under the clear night skies, shows itself on at least half of the days of every summer month and never appears for less than about one-

fifth of the time during winter. The period of maximum rain varies considerably from year to year, and depends in general on the thunderstorms that follow the summer. The rainfall graph has an unmistakable maximum in September when about three times as much rain falls as during the previous two months. Spring rains are more reliable than the autumn but only have half their average quantity. Midwinter and midsummer bring exceptionally severe droughts. The annual average rainfall is 490 mm. with an average deviation of 130 mm. either side of this, but it must be emphasized that the delta agriculture is quite independent of this rainfall.

Since the delta has developed an intense specialization, the changes of the cultural landscape during the year can be readily followed. Rice is the main interest. Human life, its prosperity and its depressions, depends on the variation in the rice crop and on the fluctuations of its price. During winter only the vegetable patches on the levées remain green. For the rest, the yellow fields lie bare with the stubble of last year's rice still standing in them. Few field activities continue through the winter; it is the season of rest, of social life, of cafés. During the months January to March the stubbled fields and the old straw are burned. Enormous fires at times break the clear flatness of the delta with great smoke clouds. This burning acts as a fertiliser by returning some of the elements which plants have already taken from the soil. Generally in the month of February the land is ploughed deeply with a modern steel plough drawn by three or four horses or a hired tractor. This is the only field process where mechanization has come into play and can do so only because at this time the fields are dry and firm. No mechanical means has yet been devised to work when the soft alluvium is under water. After this deep ploughing the soil is worked over carefully to a fine tilth with the help of the *tabla valenciana*, a board with steel cutters underneath which, when drawn across a newly ploughed field, quickly reduces it almost to a powder.

The fields remain thus until the first days of April, when they are flooded from the canals whence the water enters by means of the brick channels which stand up above the field surface. At this stage about one-twentieth of the area is separated off by low earth dykes to serve as seed beds where the rice plant begins its early stages. The fraction thus devoted to *planteles* is exceptionally large because late frost normally kills off many of the young plants. The seeds used are mostly taken from the farmer's last crop. In the best practice, seed-stock is renewed each three years with seed from the Government experimental station in Valencia. It takes a complete season to acclimatize this seed to the cold Ebro conditions, and for this reason many farmers import seeds from the North Italian plain where conditions for rice are more difficult than those in the Ebro. That seed improves by coming to the milder conditions of this delta and resists the frost to which the area is periodically liable. The *planteles* are flooded lightly and the seed sown by hand. Some days later the seed bed is treated with a heavy fertiliser. Meanwhile the flooded rice fields themselves are worked over repeatedly with another type of *tabla valenciana* to break up the surface and kill off the many aquatic weeds which assert themselves rapidly. During the latter part of May comes the heavy labour of transplanting the rice from the *planteles* to the fields. By this time the plant is some 20 cm. high. The young plants

are dumped in heaps upon the upraised edges of the fields until required and then planted in the flooded soil by hand. Three or four plants in a bunch are put in separated by about 25 cm. from the next bunch. This completed, the field is further flooded until it appears nothing but a muddy flat. Both sexes take part in the heavy work of transplanting the rice. Men are preferred, and a great number of workers come from Valencia to take part because in Valencia every process of rice cultivation is two or three weeks in advance of the corresponding stage in the delta. Thanks to this labour the whole work of transplanting can be completed in a fortnight, after which the imported labourers return south. The working in flooded fields with bent backs and bare feet by men in large straw hats, blouses, and with sashes wrapped repeatedly round their waists, gives a peculiar oriental aspect to the landscape.

From this time until the beginning of July activity is small since there is little to do except keep down the excessive growth of weeds. The fact that rice is only in the field for some eight months, of which only three months require great activity, causes the population to retain much interest in fishing and hunting. That is one of the effects of the great flocks of birds on the fringes of the delta and of many water channels which are alive with fish of many types. During this period of summer ease only one critical factor has to be watched. A persistent and very dry north-west wind coming from the heated interior may continue for so long as to dry up the rice plants during the important floration period. Apart from this there is little for the farmers to worry about. At the beginning of July the fields are again heavily fertilised. There is no fixed rule for this manuring, but it generally occurs two or three weeks after replanting. The second fertilizing is a much heavier one than that used on the *planteles*. The chemical fertilizer is scattered over the flooded fields by hand. After fertilizing, the plant progresses at a rapid pace; unfortunately, so do the weeds. To remove these women labour assiduously in the fields and the weeding must be repeated many times from the beginning of July until the middle of August. During the second fortnight of August the rice has reached such a height that the workers cannot move among it without danger of breaking the plants. They then keep off the fields and use the time to clean and put in order the smaller canals or to cultivate the *huertas*. Nominally the cleaning out of the ditches should be done by the syndicate of canals. Their work is often incomplete so that farmers are forced to do it themselves if they wish to avoid providing breeding grounds for mosquitoes.

In September comes the rice harvest. Eight or ten days beforehand the field is dried out, or rather flood waters are led off. It is not a perfect drying because peculiarities of the sub-soil conserve a moist surface for a long time. Some fields are dry ten days after interrupting the entry of irrigation water, while other fields need seven weeks before signs of surface drying appear. The harvest practice here is not like that in Valencia. Cutting in the delta is entirely by hand while the soil is still very wet, sometimes while still partially flooded. Firstly, the head of the plant is cut off that there may be no risk of falling to the ground and dampening the ears. Secondly, a low cut kills the plant, leaving all its straw to yellow the dull earth. Into the harvest every worker and child on the delta is pressed, and labourers from Valencia return

again to this harvest work, sleeping at night under conditions and congestion which are even more unhygienic than those which used to occur among Kentish hop-pickers. Mid-September sees the final shutting of the canal sluices, but since the rains set in about the same time it is not infrequent to see the delta as one shining lagoon fretted by the network of ridges from the saucer-like form of each field. Transport by lane at this time is nearly impossible. By November only a coarse stubble remains in the fields as a reminder of the rice which now gives seasonal occupation in the de-husking mills in Amposta, Aldea, and Tortosa, or lies in sacks, stacked in the local warehouses. At this time on threshing floors can be seen remnants of wheat straw and piles of empty rice ears after they have been threshed by hand; and there are generally seen, too, the husks of maize which is grown for the local domestic animals. There are many chicken about for the grains which escape gleaners. Farmyard ducks and geese, unusual fowls for Catalunya, abound, living on the multitudinous frogs that fill the water conduits. The beginning of harvest is very regular through the years, being started punctually and invariably in the last week of September.

Rice constitutes the wealth of the region and is a function of natural conditions and the imposed system of irrigation. Beside the actual cultivation comes the industrial activity of de-husking and elaborating the rice which is done by some twenty mills in Amposta, Tortosa, and San Carlos in this order of importance. These mills take their power from the Catalan grid of electricity which is fed by generators on the River Segre. These factories have as tall a chimney as if coal were the source of power; the chimney serves to burn the husks and to provide draught which carries off the clouds of dust that arise during the processes of rice cleaning. Into this enter the various systems of communication already mentioned. There is still a strictly seasonal use of the lower Ebro for transport. Shallow, flat-bottomed boats, driven by long oars or single-masted sails, slowly carry 7000 tons or so of rice up-river to Amposta and Tortosa in the autumn. They come down again in early spring to help shift cheaply the heavy loads of fertilizer from those towns out into the delta. Fishing on the river has nothing but local importance; the flooded rice fields commonly contain trout which do considerable damage by eating the young rice shoots. One of the important qualities of the regional rhythm is the migration of outside labour at transplanting time and at the harvest. This labour is a masculine migration; the men stay for not more than a month on each occasion and come mainly from Valencia. Many labourers come also from the olive-growing areas immediately adjoining the delta, since the olive picking does not occur until long after the rice harvest. These labourers bring nothing but their labour to the delta, leave nothing but the products of their labour, and take away cash. Many men who come are owners of small farms in poor parts of the surrounding country, yet there is naturally a preference for labourers from Valencia who are experienced in the special activities associated with rice. Exact numbers of the men who come are impossible to obtain; it is estimated that nearly three thousand men come each time. They live very simply during their stay on the delta so that there is absolutely no arrangement of inns or lodgings to receive strangers. A further phenomenon of the delta is the regular movement of

great flocks of birds, moving southward along the east coast of Spain away from the cold winters of Europe. Of these birds, starlings are the most numerous, arriving with punctuality at the beginning of October and normally remaining to feed on the delta insects until early spring.

The vegetables cultivated in the delta are destined for strictly local purposes, providing the ordinary food of the delta population and only being sent for short distances by cart to the villages immediately adjoining the delta. The rice forms by far the greatest influence upon the surrounding regions. It enters largely into local diet and brings into Southern Catalunya a variety of special dishes otherwise associated only with Valencia. This predominance of rice diet extends as far as Tarragona in one direction and to Mora in the other. The production of rice is so great that the local consumption is but a small part of it. Most of it is exported to other countries, of which England has hitherto taken first place. The export of rice is done from San Carlos and is the only stimulus to trade in that otherwise isolated town. The rice distributed to the interior of Spain enters into circulation by railway from Aldea and Tortosa. This rice mainly moves in northerly directions since Valencia serves most of Southern Spain. Tortosa can by no stretch of the imagination be considered part of the delta region, yet it is the rice crop of the delta which conditioned the richness and modernity of Tortosa. This town has been the great centre of interchange between an olive-growing region and the delta. In an average year about 75,000 metric tons of rice are produced on the delta of the Ebro. The enormous quantities of water used on the delta relate it to the regime of the river. The Ebro, despite the many types of country from which it receives its waters, is definitely a Mediterranean river in so far as late summer finds it with little water. There would be much less water at that season if it were not for the various dams in the higher reaches which preserve its waters from lowering to a mere trickle. The last of the dams is that at Cherta, whence the delta takes its water. The requirements of the delta are unfortunately at a maximum when the river is at its lowest ebb. The rice must be continually irrigated from April to September inclusively and takes from the river about 600,000,000 cubic metres per annum; the *huerta* takes 35,000,000 cubic metres per annum. The cost of this water does not play a very large part in the economics of rice. The actual cost of the water varies slightly from year to year, yet roughly the dues are 8 pesetas per annum per half acre of *huerta* and 10 pesetas per annum per half acre of rice. Since nearly 1200 kilograms of rice are produced from each of these units of area, it is obvious that the water costs are almost negligible. The methods of organizing the distribution of water are entirely in the hands of a society that is almost cooperative and known as the Mancomunidad de Regantes. This society is one to which all consumers of irrigation water are compelled to belong. The society is the direct holder from the State of all rights connected with canalized waters. It made the original suggestions for canals, and drew up with the help of its experts the necessary plans. The State then examined the proposals to see whether they infringed the rights of other people using the river and finally gave the Mancomunidad authority to raise the necessary funds and to act as entrepreneur between the financiers, the engineers, and the cultivators. All dues, all supervision of the *acequias*

and *desagues*, all arrangements for extending the conduits, are entirely the responsibility of the Mancomunidad de Regantes.

The predominant factor of rice is the need for manure which is almost exclusively chemical. For this the delta depends entirely on outside areas, particularly on foreign countries. At Flix there is a chemical manufactory on a large scale, but owing to the great detour which fertilizer must make to reach the delta (Flix–Tarragona–Tortosa, a rail journey some six times greater than the straight line from Flix to Tortosa) and to the heavy cost of rail transport, the delta takes its fertilizers firstly from England, secondly from Germany. The point of entry is Puerto de Alfaques, where there is a regular service of boats bringing fertilizer and carrying away rice. The delta consumes about 18,000 metric tons of fertilizers per annum.

As always, when the life and economic outlook are devoted entirely to one crop slight changes of trading positions bring about serious crises. At present the crisis in the delta is very severe, for several reasons. Firstly, there is over-production: a quarter of the Spanish rice crop is produced in this delta and the great success which early rice growers had led to the investment of much money in rice. Secondly, the rice costs of the delta are very high in comparison with those of oriental rice so that on the international market Spanish rice has a disadvantage. The present low exchange rate is not sufficient to counteract the high labour and fertilizing costs in the delta. Thirdly, the complicated system of preferential tariffs in foreign countries adds to the difficulties which confront the entry of Spanish rice abroad. The delta has been much affected by the introduction of Empire preference in England whither most of the Ebro rice previously went. The local attempts to overcome the effects of the crisis are similar to those which have been tried elsewhere. The great trouble is to prevent undercutting of prices by the small farmers with immediate need for money. This undercutting is especially difficult to control because most farmers have taken credit from dealers to buy fertilizer, on condition that they repay the dealers in rice. Since the price of this rice is considerably less than the market price, which permits the dealer to undercut the market and profit at the same time, the dealers in rice are invariably the dealers in fertilizer as well. The delta, in particular, suffers from the fact that its harvest is three weeks or so behind that of Valencia, consequently its rice comes to the market quite late. In a time of price difficulties the first on the market holds an overwhelming advantage.

Having thus enunciated the essential deltaic character, we may turn to the question of delimiting the region. Eastward, the perfectly natural boundary is the sea. Landwards, it seems advisable to take the strictly geological boundary between the recent alluvium and the quaternary conglomerates. On the east of this boundary the land is perfectly flat, without a sign of hard rock at the surface; it is subject to periodical floods and to irrigation. On the conglomerates, which rise sharply in a small cliff never more than 5 metres high, is a shallow, reddish soil that contrasts with the dull yellow soil of the delta. The hard conglomerate appears at the surface at every 2 or 3 metres, and the agriculture follows the principles of dry-farming. On this land the landscape is definitely wooded, while the main railway line and the roads give an entirely different character to the cultural setting. In one place, between

Amposta and San Carlos, an outlier of dolomitic limestone from the Sierra de Montsia brings pinewoods and dry maquis down to the delta boundary. Three villages, Ampolla, Amposta, and San Carlos, each at a vertex of the deltaic rhombus, present some difficulty in classification. Although they are closely related to the delta they are themselves marginal to it. Strictly speaking, none of them can be definitely included in any one of the natural regions which they adjoin, and their activities mostly reflect the inter-actions between the regions rather than the regions themselves. San Carlos is occupied by fishermen and by those who work the *salinas*; very few people in this village are concerned with the special agriculture of the delta. Ampolla is likewise predominantly a fishing village, whose pre-occupation with drought, owing to the absence of ground water, and whose interest in olive cultivation round the village, are sufficient to justify its exclusion from the delta. Amposta ranks differently: its interests, and by far the greater portion of its municipality, are in the delta, although it takes its site on an outlier of conglomerate which gives it some protection from floods. Eastward and westward of it lie new alluvial soils and rice or *huerta* cultivation; eastward lies the delta proper; westward stretches the narrow strip of marshy land through which the Ebro passes on its final riverine course. Amposta is the shopping and marketing centre for all the southern delta and its interests, added to its position, rank it as the town of the delta. Thus this clearly demarcated unit stands out as one quite distinct from all its surroundings, a region which is unique in the whole of Catalunya. Although in detail the Ebro delta has certain individual characteristics, it may best be described as an outlier of the famous *huertas* of Valencia.

REVIEWS

EUROPE

LA TCHÉCOSLOVAQUIE: étude économique. By ANDRE TIBAL. (Collection Armand Colin, N° 183.) *Paris: Armand Colin* 1935. 7×4½ *inches; 224 pages; maps.* 10.50 *fr.*

Professor Tibal, who at one time occupied a professorial chair at the University of Prague, writes with the warmth of a partisan, though he does so without distortion of fact. In his introductory chapter he gives an account of the various stages in the historical struggle for independence on the part of the Czechs, and follows this up with an account of the formation of the Czechoslovakian Republic after the Great War. These two chapters, with their interesting sidelights on the national character and on Masaryk, Beneš, and other Czech statesmen, are among the most vivid in the book, and they provide the necessary background for the study of Czechoslovakia's economic strength and weaknesses. The remaining chapters include such subjects as the ethnic minorities, agrarian reforms, agriculture and its associated industries, mineral wealth, industrial development, finance, and so on. The last chapter, on the position of Czechoslovakia in Central Europe, does not hesitate to point out the difficulties of the international situation in both its political and economic aspects.

The author has obviously been hampered by the small space at his disposal. The subject is in fact too large for the size of the volume. Only nine pages are given to the geographical description of the country, and though a double page is devoted to a sketch-map, the section suffers from over-compression. The volume may be looked upon as a satisfactory introduction to the subject, but whenever the author digresses a little, as he does here and there throughout the book, *e.g.* in the brief biography of Thomas Bat'a, it becomes apparent what a very interesting book he could have written if he had had more room to spread himself.

M. R. M.

CENTRAL AND SOUTH AMERICA

THE SOUTH ORKNEY ISLANDS. By JAMES W. S. MARR, M.A., B.SC. Discovery Reports, vol. X, pp. 283–382, Plates xii–xxv. *Cambridge: University Press* 1935. 9×12 *inches.* 15*s*

The Discovery Committee, which under the authority of the Colonial Office directs the systematic study of Antarctic whales, takes a view of its functions which is both wide and wise. The two specially equipped vessels *Discovery II* and *William Scoresby* are officially styled Royal Research Ships and the records of the work done in them are produced and published by the Cambridge University Press in handsome quarto volumes, which excel in dignity even the famous Challenger Reports. The useful concession of publishing each memoir as a separate part of the volume to which it belongs justifies us in singling out for special notice the most recent of the valuable geographical studies. Other geographical memoirs which were necessary to the full study of whales and whaling have already appeared in this *Journal* in the form of papers read to meetings of the Royal Geographical Society. Our readers are thus familiar with the thorough way in which the members of the scientific staff present the results of the accurate surveys and systematic observations carried out during successive commissions of the research ships.

This important memoir is a complete description of the South Orkney Islands, a typically Antarctic group though lying far outside the Circle. The first part is historical, tracing the various voyages of seal hunters and explorers from the records of scientific expeditions and the tangled yarns of the early sealers. This is conspicuously well done. Thanks largely to the assistance rendered by Lieut.-Commander R. T. Gould and largely to the researches of the author amongst the archives of the Hydrographic Department and of other official bodies a larger amount of trustworthy evidence has been marshalled than had previously been possible. Mr. Marr deals fully with the discovery of the group by the British sealer Powell in the *Dove* along with the American sealer Palmer in the *James Munroe* during the Southern summer of 1821–22, and he appears to have settled finally the relative shares of the explorers. In his treatment of the independent discovery of the islands by Weddell later in the same season and of the subsequent visits of French, British, German, and Norwegian expeditions he follows the scientific method of treatment entirely free from any colouring of prejudice or partisanship.

Before the twentieth century only the northern shores of the South Orkney group and the straits between the two main islands had been roughly surveyed. Bruce's *Scotia* expedition in 1903–5 made an excellent and nearly complete chart of Laurie Island, which the subsequent work of the *Discovery II* confirmed and extended to Coronation Island, the western and largest member of the group. This island had been visited by Norwegian whalers of the modern period who surveyed Signy Island off its south coast. The *Discovery II* had the privilege of mapping it in detail for the first time and of showing its close resemblance to Laurie Island in outline and configuration. How much the *Scotia* and *Discovery II* have done in the way of detailed surveying may be judged from the fact that Fricker in 1900 calculated from the best maps then available that Coronation Island had an area of more than 500 square miles and Laurie Island of more than 200 square miles. This was a reasonable deduction from the known length and probable breadth of the islands; but the new map which accompanies this memoir shows that the coast-lines twist and turn in such an intricacy of long peninsulas and cove-fretted bays that the two islands are reduced to land areas of only 130 and 25 square miles respectively.

The climate of the South Orkneys is known better than that of any other Antarctic land on account of the enterprise of the Argentine Government in maintaining to the present day the meteorological station established in 1903 by Mr. R. C. Mossman of the *Scotia* expedition. The essential peculiarity is that the islands have a mild oceanic climate in summer and an intensely cold "continental" climate in winter, when they are usually surrounded by a close ice-pack continuous over the whole Weddell Sea and often reaching far to the north of the islands. The southern coasts are icebound for more than half the year, while the ice may be blown away from the north coast for weeks at a time even in the depths of winter.

An excellent account is given of the glaciology of the islands, the central mountains being covered not by an ice-cap but by a thin ice coating which does not conceal the configuration of the underlying rocks. Deep lateral valleys separated by narrow ridges contain short glacial masses not fed by any extensive snow-field but filling the lower part of the valleys and often reaching the sea in cliffs over 100 feet high. These ice-foot glaciers have no perceptible forward movement, but at the lower ends the ice from contiguous valleys may coalesce laterally to give extensive stretches of continuous ice-cliffs. The land forms are largely dictated by a very pronounced jointing of the ancient metamorphic and igneous rocks giving rise to stepped rock terraces sometimes forming huge

precipices the faces of which are smooth joint planes. While the minor features of the exposed land bear unmistakable marks of severe frost-erosion and recent ice action, often of a kind peculiar to the region, there is evidence that the larger features were eroded by a far more intense glaciation than the present accumulations could account for. Extensive raised beaches bear witness to great changes of level in a recent geological period.

Mr. Marr brings the extensive echo-soundings of the *Discovery II* to the elucidation of Suess's supposition that the Andes mountain structure is continuous with that of Graham Land. The connection is shown to be not direct but through the remarkable sweep of the Scotia arc through the Falklands and South Georgia, then eastward to the South Sandwich Islands, southward to the South Orkneys, and finally westward again by the South Shetland group to Graham Land. The full detail of the submarine ridge which bears this island arc is not yet complete; but the research ships should still have time to use their echo-sounding gear in the few remaining blanks of the bathymetrical chart.

The memoir goes on to consider tides, though for this the available data are still inadequate. The botany of the group is quickly summarized, as no plants higher than mosses exist, although these and a green lichen simulating grass cover many acres in certain ice-free stretches near sea-level. More detail is given to the fauna, especially to the seals, and the tragedy of the extinction of the fur-seal in its last retreat is touched on. The plates from photographs are excellently produced and the scenery shown has been selected to represent typical examples of rock and ice formations. Mr. Marr is to be congratulated on the balanced proportions of his work and on the equal stress he lays on the various subjects dealt with. Indeed it would be difficult from this paper for any one ignorant of the author's work as a biologist to guess in which branch of science he is a specialist. H. R. M.

DIE WEISSE KORDILLERE. By PHILIPP BORCHERS and others. *Berlin: Scherl* 1935. 9×6 *inches;* 396 *pages; illustrations and maps. M.*12 (*unbound M.*9.50)

The full story of Dr. Borchers' expedition, now given in a volume of nearly four hundred pages, is a model of clear, vivid description, the value of which is enhanced by the more detailed geographical, ethnological, and scientific appendices which constitute the second half of the book, and by an admirable map on a scale of 1 : 100,000, based on photogrammetric survey, with the aid of which it is easy to follow the course of the travellers. As far as is possible, local and traditional names are preserved.

The expedition was intended for scientific as much as for mountaineering purposes, and Herr Hoerlin, after taking part in the ascents of Huascaran and Chopicalqui, devoted himself to the study of cosmic rays, in the course of which he spent three weeks at heights of some 18,000 to 20,000 feet. The original plan was to explore the range systematically from north to south, but since the early season was exceptionally bad (there being this year no settled weather before July 1) little mountaineering could be accomplished before the party reassembled at their headquarters in the Santa valley for an attack upon Huascaran, the highest point of the range. Furthermore it was necessary to train their porters both in weight-carrying and in mountaineering technique. The first corps of porters proved unsatisfactory; the second corps, formed before the ascent of Huascaran, entered fully into the spirit of the expedition, and it is good to read of the happy association between the natives and their European visitors.

With the ascent of Huascaran the spell was broken, and there follow ascents

of several hitherto unclimbed peaks. Herr Schneider gives a most interesting account of the ascent of Huandoy. The east face was examined by the climbers at the end of July. "We saw," writes Dr. Borchers, "a classic model of an avalanche-trough, beneath a cliff of rock and ice; the only possible line of ascent was threatened by a huge overhanging sword of ice, which might fall at any moment." For hours they debated whether to attempt this passage, but in the end, despite a belief in their lucky star, prudence prevailed, under the influence of Herr Hoerlin, who had himself, with Herr Hein, turned back before avalanche danger when within 100 feet of the summit of Contrahierbas. Early in September, after vainly exploring every other approach, Herren Schneider and Hein returned to the east face. "The ice-cliff," writes Herr Schneider, "looked just as unpleasant as at the time when we sat on the moraine and considered possibilities. The great *Eisklotz*, which had then given us grave anxiety, was still hanging on the cliff which closes the great gully, the *Kanonenrohr* as we then christened it. And this gully was the only possibility of getting through the ice-wall. So there was nothing left but to try it." It is not surprising that, after a brilliantly swift ascent of the peak, their enjoyment of the summit-view should be disturbed by a prospect of the descent. When they looked back upon their peak twenty-four hours later, they noticed that the *Eisklotz* had fallen.

The book is a worthy memorial of an expedition so carefully planned and successfully carried out. Nevertheless, familiar as we are with the heroic feats of post-war German mountaineers in foreign lands, it seems hardly necessary or in keeping with his scholarly attitude towards travel for Dr. Borchers to emphasize the new spirit in Germany which he records on pp. 20–21, or to refer to changes in the national flag.

A spirit of whole-hearted co-operation, of response to clear, decided leadership is the note of the whole book. Dr. Borchers and his companions deserve our congratulation for their success and our gratitude for a book of travel which one is reluctant to lay aside. H. E. G. T.

POLAR REGIONS

THE VOYAGE OF THE *CHELYUSKIN*. By Members of the Expedition [O. J. SCHMIDT and others]. Translated by ALEC BROWN. *London: Chatto and Windus* 1935. $9\frac{1}{2} \times 6$ *inches;* xiv+326 *pages; illustrations and maps.* 18*s*

The *Chelyuskin*, a 4000-tons iron cargo vessel, was ordered to sail from Leningrad round the North Cape and along the Siberian coast to Vladivostok, calling at Wrangel Island on the way. She sailed in 1933 and was caught in the ice, crushed, and sunk in February 1934; and her mixed ship's company spent two months on the ice before they were rescued, skilfully, bravely, and very dramatically by Soviet aviators. This book has now been compiled from accounts by various members of the expedition, and presented to the world as the record of a heroic attempt which only proved a failure owing to the overwhelming odds against it.

The initiative for the expedition came from official quarters, the Soviet authorities wishing to show that the North-East Passage is a practicable trading route. The vessel chosen for the task in 1933 was a high-powered cargo vessel, not an ice-breaker, as might have been expected, as these are unsuited for long-distance work. Dr. Schmidt, the well-known polar leader, was in charge of a mixed party of about a hundred, consisting of some members of the Communist Party, more non-members, and several women, one of whom bore

a child during the voyage. Dr. Schmidt writes, "In my opinion the participation of women in such expeditions is completely permissible. To speak plainly, I should only prefer men for such hard work as cleaning the ship."

For about half her voyage the *Chelyuskin* sailed in company with the ice-breaker *Krassin*, which was then obliged to turn back for repairs. Of two other ice-breakers one was in an unsatisfactory condition and the other busy at Cape Chelyuskin; and it was finally decided that the *Chelyuskin* should risk going on alone. The collective was determined at all costs to fulfil the work assigned to it, and the ship was actually nearing Bering Strait when she was finally gripped by the ice and carried helplessly by wind and current. There were several false alarms before the coming of the inevitable end; but the scientists calmly observed the ice-pressure even while it crushed their ship. The abandonment of the quickly sinking vessel was most competently done. An adequate camp was made upon the ice: and since it was impossible—owing to the presence of the women—to travel the 150 km. over rough ice to the Siberian coast, the party stayed where they were and waited with complete confidence for Moscow to arrange for their rescue. And thanks to really remarkable flying their confidence was justified.

The voyage was in fact a failure: that is to say, the *Chelyuskin* did not accomplish what she originally set out to do, whatever scientific data were collected or whatever courage and skill were demonstrated in the consequent rescues. In the year following four ships however made the North-East passage, suitably equipped and prepared. Nevertheless the Soviet authorities who planned the expedition could not have been disappointed by the earlier happenings. The *Chelyuskin* received far more publicity than the other ships which have since made the voyage and original intentions were forgotten in the world's appreciation of a happy ending. In the words of Alexander Pope "an ornament was extracted from an inconvenience"; and if the voyage of the *Chelyuskin* is unimpressive as a trading venture it remains not the less impressive as a failure happily repaired.

ECONOMIC AND HISTORICAL GEOGRAPHY

ROBERT BLAKE, sometime commanding all the Fleets and Naval Forces of England. By ROGER BEADON. *London: Edward Arnold & Co.* 1935. 9 × 5½ *inches;* 308 *pages; illustrations.* 15*s*

Before the middle of the eighteenth century the memory of the great Admiral of the Commonwealth, as Mr. Beadon writes in his preface, had passed "out of party into national keeping." In the sixteenth century England had helped to open the seas to the enterprise of the northern nations; in the seventeenth she had learned the significance of Halifax's words "Look to your moate"; in the eighteenth, with the expansion of her power and commerce, naval policy had assumed that pre-eminence in her outlook which enabled her to appreciate the greatest seaman as yet in her annals. Born towards the end of the reign of Elizabeth, Robert Blake was educated at King James Grammar School, Bridgwater, and at Wadham College, but he does not appear in public life till he was elected member for Bridgwater in the Short Parliament of 1640. Three years later he was one of the garrison that surrendered at Bristol to Prince Rupert. Some years of soldiering in the west followed and then in 1649 came the change to the fleet. In that year Colonels Popham, Blake, and Deane were appointed commissioners for the ordering and commanding of the fleet. Blake had faced Prince Rupert on land and was soon to face him on sea, for Prince Rupert had

taken the command of the Royalist fleet which was to be turned against English trade. It was Blake's first achievement to break the Royalist power at sea. A larger task followed, for Anglo-Dutch relations had gone from bad to worse, and in 1652 the Commonwealth was at war with the United Provinces. The victory over the Dutch which gave England command of the sea and raised her to the rank of a first-class power in Europe is Blake's chief title to fame. English naval power was appearing and he was one of its chief architects. In that year Blake fought not only in the narrow seas but he carried the English flag into the Mediterranean, whither he was sent again in 1655 on a memorable voyage which revealed the significance of the rising naval strength of England. A powerful fleet was equipped to strike at Spain in the war which Cromwell declared in 1656, and Blake's last naval action was the destruction of the Spanish treasure fleet at Santa Cruz in Teneriffe in April 1657. On the journey home he died at the entrance to Plymouth Sound. He had revealed what naval power meant, shown the seamen "what mighty things they could do if they were resolved," and placed England on the road to its attainment. Thus he holds a secure place in English history. It is strange that so large a part of his life is lost in obscurity and that we should not know whether one of our greatest sailors was in any sense bred to the sea, or whether one of the greatest servants of the Protectorate shared the politics of his masters. "It is not for us," he is reputed to have said, "to mind state affairs, but to keep foreigners from fooling us." Mr. Beadon has given a very pleasant and balanced account of this great and singular career. He has interested himself more in the man than in the tactics of naval warfare. His narrative would have gained by compression, but it will be read with interest and the book is pleasantly illustrated. E. A. B.

DER MENSCH ALS GESTALTER DER ERDE: ein Beitrag zur allgemeinen Wirtschafts- und Verkehrsgeographie. By EDWIN FELS. *Leipzig: Bibliographisches Institut* 1935. 10×6½ *inches;* 206 *pages*

As Dr. Fels states in his introduction this subject of Man's share in the modelling of the Earth has not been very exhaustively studied as yet, though Sherlock, Schlüter, Tiessen, Creutzburg, Schultze-Naumburg, and others have dealt with various aspects of the subject. Dr. Fels regards the matter from two standpoints, those of "Wirtschaft" and "Verkehr." The first-mentioned term, as used by him, has rather a wide scope and seems to embrace any data of agronomy, ecology, or economics which can be brought into relation with human activity, while the second may be taken to indicate the special developments due to human intercourse. What ground is in fact covered will best be understood by making a summary of the contents of the different sections of the book.

We begin by considering Man as an agent in modifying climate. Under appropriate headings there are discussed direct effects such as the attempts at defence against lightning, frost, and hail; the possible control of rainfall by explosions, electrical discharges, and the strewing of ice-particles from flying machines. Then there is the whole question of what may be called artificial climates, *e.g.* in connection with residence in polar or tropical regions, the utilization of solar energy, or the provision of suitable working conditions in factories, with, as a sort of side-line, the preparation of weather reports and forecasts. Of indirect, but more important, agencies there may be noted the destruction of forests and the feeding of springs. An account is given of the observations made by Bates and Henry from 1911 to 1926 on two adjacent areas in the Rio Grande National Forest of Colorado, one of which was cleared of trees in 1919, and of experiences in various parts of Europe and Africa. Then follows a study of the effects of water collected in seas, lakes, swamps, and rivers. Next

comes a section on the growth of towns, which are said to act in part by merely covering the Earth's surface, but also by modifying the composition, temperature, and pressure of the atmosphere, and by influencing the rainfall and the development of clouds.

The next group of facts relating to Man's activities is that connected with modifications of the Earth's land surface. Large-scale geographical features, *e.g.* mountains and plains, are little affected, but topographical details may undergo extensive alterations. This branch of the subject calls for the consideration of such topics as the effects of colonization, of mining and quarrying, the accumulation of materials, the laying out of terraces, the cultivation of the soil, and even the effects of military operations.

Water as a stimulus to human action in shaping the Earth may lead to measures of coast protection or the reclaiming of shallow water areas. More ambitious schemes for diverting the Gulf Stream, or flooding the Sahara, or damming the Straits of Gibraltar are not likely to take shape for some time. As yet indeed the sea is little affected by anything Man can do, but the case is different with inland waters and Dr. Fels surveys at some length such procedures as the alteration of ground water-levels, *e.g.* by pumping, the drainage of swamps, marshes, and flooded areas, changes in rivers and lakes, and the use of irrigation methods.

Another large field of study is provided by the distribution and growth of plants. To the three natural divisions of the land surface into forest regions, grass-lands, and desert, Man has added a fourth—cultivated land. Dr. Fels estimates that this new division at present only amounts to about 18 per cent. of the land, and while it increases steadily it will never, he agrees with Fawcett, exceed 30 per cent. Since what may be called economic geography is the department of knowledge with which Dr. Fels is especially concerned it is natural that he should devote much of his book to this subject. A short section on the relations of the animal kingdom follows, and the author then proceeds to discuss the reaction on Man of the activities described above.

The last section of the book is concerned with the effects of travel on the face of the Earth. The sections deal with natural and artificial roads, the use of water channels, the relations of plant and animal life to travel, and the special case of Man considered as a traveller. The point of view here being different from that of the last section sundry new facts have to be dealt with, but as no new principle is involved this part need not be considered at length. The book concludes with a list of one hundred and seventeen works referred to in the text. This will be found valuable, as most of the books are German, not well known in this country.

R. L. S.

THE MONTHLY RECORD

THE ROYAL PATRONAGE

The Secretary of State for Home Affairs on March 17 informed the President that he had received The King's Commands to convey His Majesty's grateful Thanks for the assurances of sympathy and devotion expressed in the Loyal and Dutiful Address of the President and Council of the Society on the occasion of the lamented death of His Late Majesty King George the Fifth, Patron of the Society.

Further, the Keeper of the Privy Purse informs the President that he has been commanded to intimate that His Majesty has been graciously pleased to grant His patronage to the Society and to continue the gift of the two Royal Medals annually.

The President has expressed in their name the thanks of the Society for His Majesty's gracious favour.

MOUNT EVEREST EXPEDITION

News from the Mount Everest Expedition has been published regularly in the *Daily Telegraph*. On March 10 Ruttledge, Morris, Gavin, Smijth-Windham, and Wynn Harris left Darjeeling for Kalimpong, followed five days later by Smythe, Kempson, Warren, and Wigram. Smijth-Windham left Kalimpong on the 15th for Gangtok, with the wireless equipment which needed special attention. The rest of the Expedition was entertained on the 18th, the day before their departure for Tibet, by the Maharajah of Sikiim. A week was spent acclimatizing at Tangu, the last bungalow in Sikkim, where the new oxygen apparatus and the high-altitude wireless set were tested. The expedition then made its way up the Lachen Valley, instead of the Chumbi Valley which was the route taken by the 1933 Expedition; and the two 17,000-foot passes of Kongra La and Sebu La were successfully crossed on April 2. On April 19 the expedition was in camp at Tengkyi Dzong, where they received, through the Viceroy, a telegram from His Majesty the King, wishing the expedition good fortune and success.

THE BRITISH GRAHAM LAND EXPEDITION

The Graham Land Expedition is beginning its second season's work. They have established a new base on the mainland in Marguerite Bay, over 200 miles south of their old base in the Argentine Islands; and the *Penola*, with a skeleton crew, has returned to Port Stanley for an overhaul.

Last winter the party of sixteen men appear to have done little travelling. Strong currents flowing between the islands prevented the sea from freezing in many places and made sledging difficult. Only short journeys could be made to the east, north, or south. Apart from the surveyors however the scientists appear to have found plenty of material to work on.

Throughout the winter members of the ship's party were at work repairing the engines, which had been found to be out of alignment. On January 3 the ice had melted sufficiently for the ship to move, and she set off for Deception Island to pick up the mail left there by Mr. Lincoln Ellsworth.

When this voyage had been successfully accomplished the *Penola* sailed southward, on February 18, to find a new base for the expedition. With the aeroplane to assist navigation through the ice the *Penola* forced her way southward to lat. 68° 8′, long. 66° 52′, where an excellent site for a base was found. The coast here is deeply indented, promising firmer ice, and what appears to be barrier ice to the south suggests a practicable sledge route to Hearst Land.

In a preliminary air survey (reported in *The Times* of April 17) new land was seen to the southward, and Rymill has said, in a private message, "we are in a strong position here and expect a fruitful year."

When men, dogs, and stores had been disembarked the *Penola* turned northward and sailed to Port Stanley, where she will remain, probably until January 1937. No official information of how the party has been divided is available, but it appears to be as follows: Land party (remaining at the new base) Rymill, Meiklejohn, Fleming, Bertram, Moore, Riley, Bingham, Stephenson and Hampton. Ship's party (at Port Stanley) R. E. D. Ryder, L. C. D. Ryder, Millett, Martin, Gurney, Roberts, and Carse.

Every one is in good health and spirits, and hopeful for the future.

SHELL-HEAPS AND COASTAL STABILITY IN NEW ENGLAND

In a short article in the *American Journal of Science* for July 1935 Richard P. Goldthwait brings interesting new evidence to bear on the frequently discussed problem of the stability of the New England coast. Around the estuary of the Damariscotta River lie numerous shell-heaps, the middens of Indian tribes formerly inhabiting the area. By means of careful surveys Goldthwait has calculated the volume of these heaps, and estimated the number of shells—here exclusively those of oysters—composing them. The figure arrived at is the rather startling one of 170,000,000. The heaps lie close to the oyster-beds, and by ingenious estimates of the area and rate of growth of the latter, Goldthwait has been able to arrive at an approximate figure for the number of oysters gathered every year, and hence for the rate of growth of the middens. After making due allowance for possible irregularities in the rate of accumulation, subsequent losses due to erosion and human agencies, etc., a minimum estimate of 800 years is arrived at for the period required for the building of the heaps, and a probable figure of over 1500 years. Since the Indians deserted the area at least 300 years ago, this implies that the heaps were started over 1000, and probably nearer 2000, years ago.

The base-level of the heaps varies, but is everywhere above present high-water mark. This in itself seems to indicate that there has been no appreciable sinking since the heaps were started; but more conclusive evidence is afforded by the fact that if the coast had been sinking steadily, *e.g.* at 1 foot per century as estimated by many authorities, the oyster beds would have been cut off from salt water 1000 years ago by a rocky bar which crosses the estuary, and hence could not have existed. Again where the heaps overlie salt-marsh they cover its surface almost exactly to high-water mark, but are not found below: nor are any shells found buried under marsh mud. This evidence seems to negative the possibility of appreciable rise or fall of sea-level for at least 1000 years. Goldthwait concludes therefore that since the Post-Glacial submergence which drowned the "submerged forests" common along this coast, the latter has been approximately stable, and not steadily sinking, as some authorities have assumed.

Apart from this conclusion, the paper is of general interest to physiographers as illustrating an ingenious method of utilizing indirect evidence in the study of the delicate problems connected with coastal stability. R. F. P.

DANISH NAVAL LIBRARY

Marinens Bibliotek, the Library of the Danish Navy, has issued a catalogue in two parts. Of these the first is of considerable value to geographers because of the excellent collection of literature concerning the exploration and discovery of the Polar Regions. In particular, the list of books on Greenland makes the best available bibliography for that country. The collection seems to be complete in the earlier sources, but it is noticeable that many more recently published books and papers are not mentioned, *e.g.* Captain Mikkelsen's account of the East Greenlanders or Oldendow's of the social structure in West Greenland. It would seem worth while to make at least this part of the library a standard collection, perhaps in co-operation with the Grønlands Styrelse.

A Yearly Supplement of additions is published, in which gross misprints are even more blatant than in the main catalogue, *e.g.* the British Arctic Air Route Expedition, 1930–31, under the leadership of H. G. Wilkins, Böcker for Böcher, Wagner for Wager. M. A. S.

FIFTH PACIFIC SCIENCE CONGRESS

The lavishly produced 'Transactions' make available to a wider public the work of the Fifth Pacific Science Congress, which with the support of the Government of Canada, was held at Victoria and Vancouver in June 1933. The field is a wide one, the initiation and promotion of "Co-operation in the study of the scientific problems that affect the prosperity of Pacific peoples." This aim has been interpreted very widely, and it is possible here only to give a brief indication of the contents of these five volumes. They are, unfortunately, unprovided with an analytical index, so that it is only by going through the extensive table of contents that a particular paper can be found.

Six general Congress Symposium Meetings were arranged, two dealing with recent applications of science to forestry, agriculture, fisheries, and mining in the Pacific area, and the others including discussions on air and water circulation in the Pacific area, and the fjords of the Pacific. The Congress was divided into fifteen sections, those of greater interest to geographers being Geography and Geodesy, Geology and Mineral Resources, Seismology and Vulcanology, and Anthropology and Ethnology. From the reports of the standing committees it is possible to gather the extent to which the co-operative ideal has been achieved. As might be expected, the most promising sphere appears to be that of Oceanography. Constant use only of this encyclopaedia of Pacific affairs can reveal the value of the individual papers, which must necessarily vary considerably, but this set of volumes must form an indispensable work of reference in any library which is concerned with the geography of the Pacific.

CAPITAL OF SANTO DOMINGO RENAMED

From 10 January 1936 the capital of Santo Domingo, which has hitherto been known as Santo Domingo City, has been renamed Ciudad Trujillo in honour of President Trujillo, who rebuilt the town after the hurricane of September 1930.

OBITUARY

RONALD WORTHY GIBLIN

Ronald Worthy Giblin, who died on March 7, was born in 1863 at Hobart, Tasmania, where his father was for many years Manager of the Bank of Van Dieman's Land. He chose surveying as his profession, took his examination at Sydney, and worked for ten years in New South Wales and Tasmania, gaining wide experience and considerable repute as a land surveyor. In 1894 he was selected for the Survey Department of Siam which he joined under the directorship of the late James McCarthy and, after five years of exploration, triangulation, and topographical work, inaugurated the Cadastral Surveys of Siam, having as chief assistant the late A. J. Irwin. In 1901 he succeeded McCarthy as Director and remained in charge of the Department for ten years, during which period the Cadastral Survey was extended over some 7000 square miles of rich agricultural lands and made the basis of an efficient Land Tenure System adapted from the Torrens System to suit Siamese conditions. In 1910 Giblin retired from Siam on pension and came to live in England. During the war he held a confidential appointment in the office of the Agent-General for Tasmania in London, and there came in contact with records and uncoordinated documents that inspired him to write a history of his native land. After the war he started intensive research work and acquired a great mass of material from which he constructed the first volume of 'An Early History of Tasmania 1642–1804,' which appeared in 1928, was extremely well reviewed and thought so highly of in Tasmania, that it was sponsored by the Government. After a brief visit to Hobart the author returned with renewed ardour to his work and, by the middle of 1935, had a second volume approaching completion, bringing the history down to 1836. It is much to be hoped that the second volume which had already been begun will not be lost to the public. For his services in Siam Giblin was made a Commander of the Order of the White Elephant. He leaves a widow and two sons, Major R. Giblin, R.A., and Captain H. Giblin, R.E.

MEETINGS: SESSION 1935–36

Twelfth Evening Meeting, 30 March 1936. The President in the Chair

Elections: Surgeon-Commander A. G. Bee, R.N., L.R.C.P. & S.; E. Chivers; Mrs. J. Braidwood Gray; Leonard William Hibbins; Edward Philpott Mumford; William Valentine Shearer; John Toulmin; Mrs. Margaret Watson

Paper: A Journey through Central Asia. By Mr. Peter Fleming

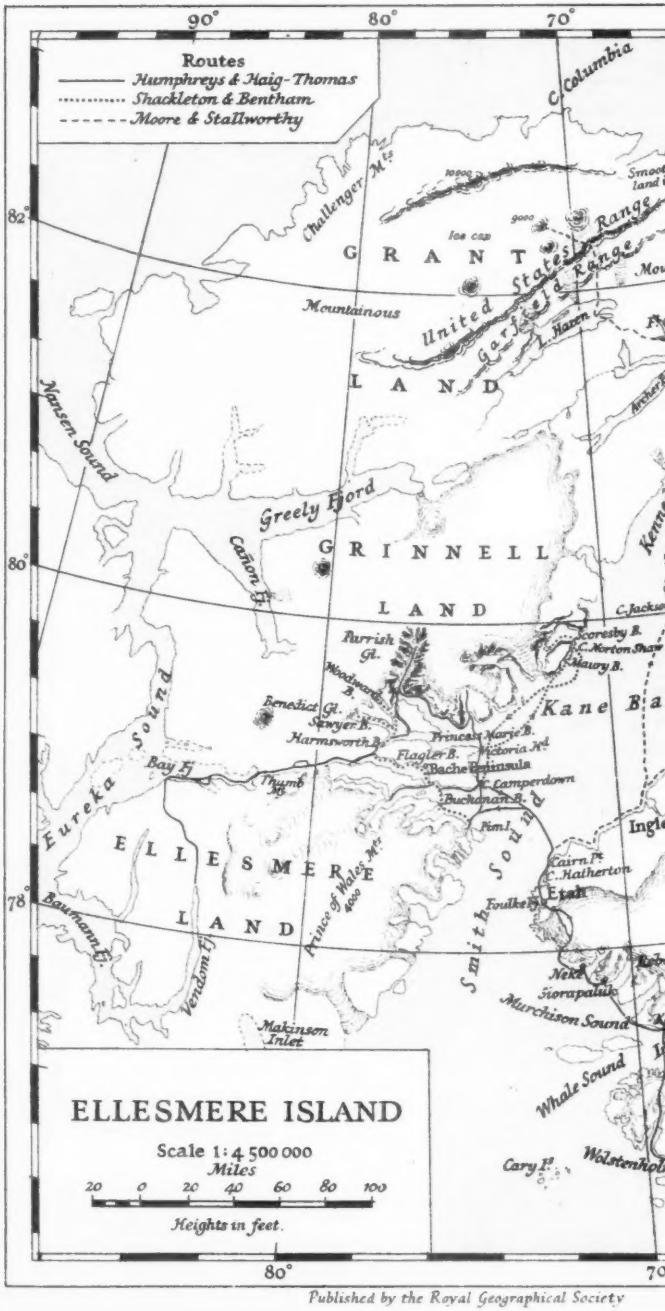
Sixth Afternoon Meeting, 6 April 1936. The President in the Chair

Paper: Surveys in West Greenland. By Mr. C. B. Hayward

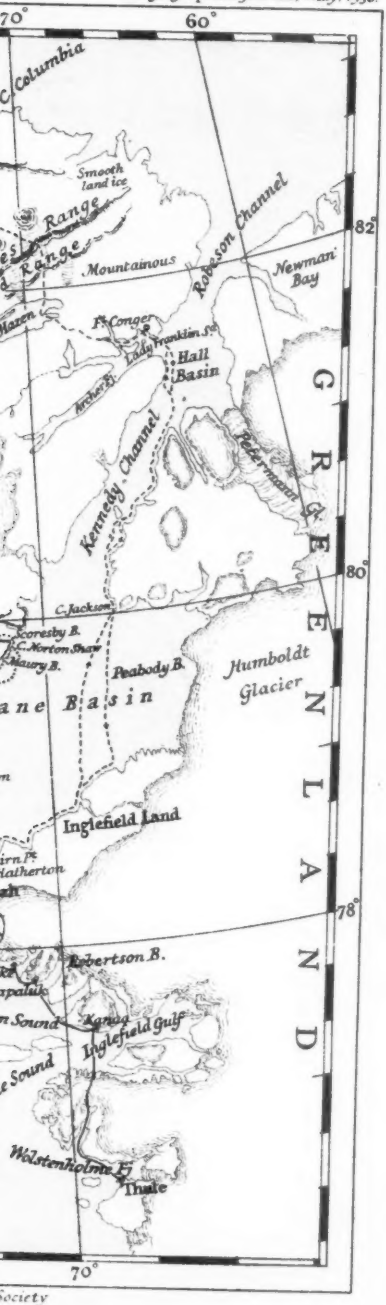
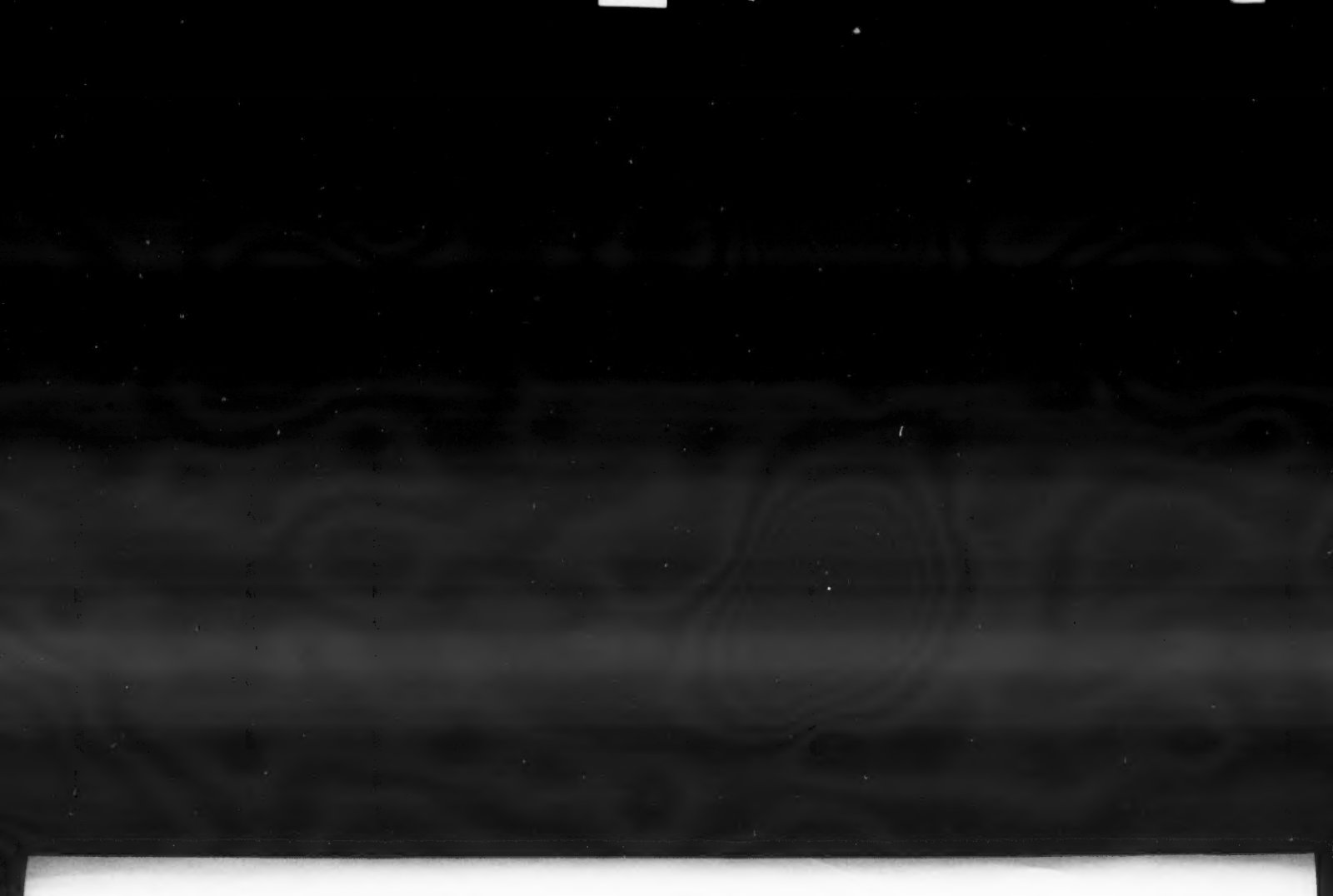
Thirteenth Evening Meeting, 20 April 1936. The President in the Chair

Elections: Miss Margaret L. Belcher; Leslie Campton; Captain H. T. Godwin, I.A.; Alfred Charles Hull; Professor Philip Willard Ireland, M.A., PH.D.; Francis Jekyll; John Willoughby Layard; W. J. Moylan; James Noble; Squadron-Leader Richard Michael Trevethan, R.A.F., F.R.MET.SOC.; S. J. Turner; Ralph Bernard Whitling; R. M. Williams

Paper: Geographical and Botanical Exploration in Tibet. By Mr. F. Kingdon Ward



Published by the Royal Geographical Society


70°
60°
C. Columbia
Smooth land ice
Range
Range
Mountainous
Robeson Channel
Newman Bay
82°
Ft. Conger
Lady Franklin Sd.
Hall Basin
Archer B.
Kennedy Channel
Petermann
G R E E N L A N D
80°
C. Jackson
Scoresby B.
C. Norton Shaw
Peabody B.
Humboldt Glacier
Inglefield Land
78°
Robertson B.
Inglefield Gulf
Wolstenholme Fj.
Thule
70°

Society